1991-03

Integration of the Peruvian Air Force information systems through an integrated LAN/WAN

Bartra Obando, Ricardo A.

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

INTEGRATION OF THE PERUVIAN AIR FORCE
INFORMATION SYSTEMS THROUGH AN INTEGRATED
LAN/WAN

by

Ricardo A. Bartra Obando

March, 1991

Thesis Advisor: Prof. Myung Suh

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School	6b. OFFICE SYMBOL (If applicable) 54
7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School	
6c. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000	7b. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)
9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS

Program Element No.	Project No.	Task No.	Work Unit Accession Number

11. TITLE (Include Security Classification)

Integration of the Peruvian Air Force through an Integrated LAN/WAN

12. PERSONAL AUTHOR(S) Ricardo A. Bartra Obando

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (year, month, day)	15. PAGE COUNT
Master's Thesis	From To	March 1991	98

16. SUPPLEMENTARY NOTATION

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17. COSATI CODES

FIELD	GROUP	SUBGROUP

18. SUBJECT TERMS (continue on reverse if necessary and identify by block number)

LAN, WAN, MAN, Broadband and Baseband Systems, data Communication, Protocols, Transmission Links, Communication Services, Transmission Media, Topologies, Access Method.

19. ABSTRACT (continue on reverse if necessary and identify by block number)

This thesis studies and analyses the surrent Peruvian Air Force information system with the view to implement an integrated network design for the existing computer based systems. The focus of this thesis is on examining the issues and factors that need to be taken into consideration for the integration design. The objective is to provide a feasible alternative for integration under the constraints of available resources and the limitations inherent to its environment.

We believe that the implementation of the recommendations of this thesis will have a substantial impact on the information systems of the Peruvian Air Force, allowing new applications to be developed including a Decision Support System on the up-to-date data. It will also permit the resolution of many problems related to data redundancy, inconsistency and non-current data..

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS REPORT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Myung Suh	22b. TELEPHONE (Include Area code) (408) 646-2637 — 22c. OFFICE SYMBOL AS/SU

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted

All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

Approved for public release; distribution is limited.

INTEGRATION OF THE PERUVIAN AIR FORCE INFORMATION SYSTEMS THROUGH AN INTEGRATED LAN/WAN

by

Ricardo A. Bartra
Lieutenant, Peruvian Air Force
B.S., Peruvian Air Force Academy, 1988

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
March , 1991

David R. Whipple, Chairman
Department of Administrative Sciences

ABSTRACT

This thesis studies and analyzes the current Peruvian Air Force information systems with the view to implement an integrated network design for the existing computer based systems. The focus of this thesis is on examining the issues and factors that need to be taken into consideration for the integration design. The objective is to provide a feasible alternative for integration under the constraints of available resources and the limitations inherent to its environment.

We believe that the implementation of the recommendations of this thesis will have a substantial impact on the information systems of the Peruvian Air Force, allowing new applications to be developed including a Decision Support System on the up-to-date data. It will also permit the resolution of many current problems related to data redundancy, inconsistency, and non-current data.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

A. THESIS GOALS AND OBJECTIVES

In the world of growing distribution of data and machine intelligence, telecommunications will play a vital role of connecting the hardware and, just as important, the people behind the terminals. Many of the technological advances in computing and information systems will be impossible without similar strides in telecommunications. Building of the modern telecommunications network infrastructure has been likened to building of railroads in the 19th century and highways and routes in the 20th century. Due to the importance and great advantages that this technology provides, some states have begun building "digital thruways" to entice business investment.

It is highly likely that most managers will be participating in or making important telecommunication decisions throughout their career. Organizations now have more options in telecommunications, face new unregulated market systems and a need to develop their own expertise in telecommunications.

Currently we are in the middle of a telecommunication revolution. In the United States this revolution has two components: rapid changes in the technology of communications

and changes in the ownership, control and marketing of telecommunications services. These developments are inseparable. The success of the overall corporate and information system plans of large organizations requires a keen awareness of these new developments in telecommunications.

These rapid changes in technology and environment are placing a strain on many corporations and providing new strategic opportunities for others. In the 1960s, few companies had a separate telecommunications section. By 1970s the advent of time-sharing computing had made telecommunications essential to information processing systems. Telecommunications management emerged as a specialty occupation. The alternatives were relatively simple: All local and long-distance communications were handled by the reliable phone company. Communications within the firm's building were handled either by the local phone company or by the firm itself. The telecommunications managers simply had to track the cost of local calls, direct distance dialing, WATS lines, and private leased lines.

In the 1980s the alternatives were much more numerous and confusing. Entire new classes of communications equipments have emerged. Today managers must know the alternative technologies and systems available to their organizations, the cost and benefits of each, the capabilities of various

devices, and a method for determining telecommunications requirements.

All of this technology and improvements in the market place sound like a "fairy tale" to third world countries that have outdated technology and limited economic resources. To those countries, it is even more important to efficiently administer and control these resources, in peace and war times.

Telecommunications and computer technology have changed so rapidly that many nations in the vertiginous race towards more effective systems have been left behind. A memorable Peruvian writer said: "Technology is a privilege of developed countries". This remark seems to apply to the telecommunications technology. The Peruvian Air Force has established its own computer-based systems to perform its functional procedures. Even though information systems are in place, they are fragmented and incomplete. The integration issue has been addressed by the Peruvian Air Force Information Center (CINFA). However problems still exist. This thesis will describe the Peruvian Air Force's current information systems and present basic guidelines for the integration of these systems.

B. SCOPE OF THE THESIS

The goal of this thesis is to design an integrated network system to allow the interconnection of various types of

computers dispersed in Metropolitan Lima Headquarters area and in the Air Bases, Units, Air Attaches and supply offices throughout the country.

The communication links would be established using public (local, national and international) networks and government-owned communication facilities. Once completed, this network would provide an infrastructure for the adequate use of the distributed information resources in the Peruvian Air Force.

In order to accomplish the main goal of this thesis, I have set some milestones that will lead to the implementation of the integrated system .

1. Lower Level Integration

The ultimate objective of lower level integration is to select the most optimum configuration for the transport network. This can be accomplished considering the different alternatives in the OSI standards that are available to the Peruvian Air Force's Information Systems.

2. Higher Level Integration

The ultimate objective of the higher level integration is to select the best configuration for distributed applications. This can be accomplished by determining the application layer best suited for the requirements and demands of the Peruvian Air Force.

Whichever configuration is selected, it also has to conform to OSI standards.

3. Guide Manual for Integration

A secondary goal of this thesis is to create a manual that is a step by step guide to the integration of the Peruvian Air Force's Information Systems.

C. PROBLEM DEFINITION

The Peruvian Air Force has many computer centers distributed throughout the country. These computer centers work independently without interconnection; therefore all the applications that are used are not integrated. This creates the data and application redundancy problem. Another problem is the inability to update data on timely basis, causing delays and inconsistencies in data processing. These two problems are the main reasons that an effective decision making system could not be supported in the Peruvian Air Force. It is imperative to consider the integration of information systems as a solution to overcome these problems.

This thesis develops a method for the integration of the Peruvian Air Force's information systems. Once the integration happens, the Peruvian Air Force must be able to access data at various types of hosts located in different geographical locations. The integration also enhance the DSS capabilities by using real time data. The capability to use up-to-date information is critical in peace time and extremely vital in war time.

One of the main constrains in the development of an integrated system is how to avoid and prevent the access to classified data by unauthorized individuals. However the multilevel security (MLS) mechanisms will not be investigated in this thesis.

D. ORGANIZATION OF THE THESIS

In order to select the most adequate architecture for the integrated system, several factors need to be considered:

- Information systems requirements of the distinct Air Bases, Headquarters, and Units.
- Communication hardware currently used by the computer centers.
- Communication software currently used by the computer centers.
- Network architectures used in the current system.
- Description of the current applications.
- Geographical location of hosts and equipments.
- Characteristics of hosts(memory, communication capabilities, processing speed, storage capacity).
- Security measures for the classified data.
- Data transmission capability of the public networks (e.g. phone company).

The organization of the thesis is as follows. In Chapter III, we will examine the current information systems of the Peruvian Air Force with respect to these aspects. In Chapter IV, we will focus in the integration design of the information

systems. In Chapter V, we will make the conclusions and recommendations to pursue this thesis.

The logical organization of this thesis has the following structure:

- Definition of the problem.
- Compilation of relevant Information.

(1) Phone interviews with Headquarters Command of the Computer Information Systems Department in Lima Peru.

(2) Compilation of data from private companies (Peruvian Phone Company/ENTEL and CPT).

(3) Compilation of data from Data General Corp. (Main computer supplier for the Peruvian Air force Information Systems).

- Analysis of the information available.
- Evaluation of alternative integration strategies suitable to the Peruvian Air Force information systems.
- Selection of the best strategy.
- Conclusions and recommendations for the integrated system.

II. BACKGROUND

In order to provide an overview of telecommunication systems and its relation to the integrated system, this chapter will summarize the basic principles of telecommunications. It will also examine the background of the current information systems in The Peruvian Air Force.

A. TELECOMMUNICATION SYSTEMS: An Overview

1. Definition of Telecommunication Systems

A telecommunications system is defined as a set of compatible telecommunications devices that link geographically separated devices to form a network of interconnected components. A telecommunication system uses a language to achieve a meaningful communication among its components. Such language is called protocol. Telecommunication devices talk with one another through the protocol that is agreed upon communicating devices.

2. Functions of Telecommunication Systems

In order to achieve a network of interconnected devices and components, a number of separate functions are performed in a telecommunication system. A telecommunication system establishes the interface between the sender and the receiver, routes messages along the most efficient paths, performs elementary processing of the information to ensure

that the right message gets to the right receiver, performs editorial tasks on the data such as checking for errors and rearranging the format, and converts messages from one speed into the speed of the telecommunications line or from one protocol to another, and finally controls the flow of information. Many of these tasks are accomplished by computers. Most advanced telecommunication systems are virtually indistinguishable from computer systems. These two technologies meet to work together.

3. Types of Telecommunications Systems

In the United States there are several types of telecommunication systems, some of which are quite recent. One way to think on these systems is to classify them by geographical scope. The geographical coverage can range from a few meters to several thousand kilometers.

a. Local Networks

Local Networks tie together computer and other devices over areas ranging from a few meters up to several square city blocks. This particular classification includes private branch exchanges (PBX), and Local Area Networks (LAN).

b. Metropolitan Area Networks

Metropolitan Area Networks (MAN) link together components, computers and devices over areas ranging from several city blocks to entire cities.

c. Long-Haul Networks

The interconnection among cities, countries, and large distances is achieved by long-haul networks. The typical long-haul networks are public switched telephone systems and value-added networks.

B. NEED FOR AN INTEGRATED SYSTEM

Since the availability of consistent real time data has a vital importance for many applications, it becomes a critical success factor in information systems including those of the Peruvian Air Force. The military requires classified information in a very short notice, not only in the Tactical area but also in the Operational and Administrative areas, to make important decisions. For instance, the current events in the Persian Gulf has proved the importance of communications. By having real time information, we can make decisions based on the knowledge of what we have available. Logistics, for example can not be effective without an integrated system that supports it.

The widespread use of digital computers has led to the development of reliable data networks. These data networks are usually operated by common carriers. The phased development of the telephone and data networks in different countries has led to minor differences in implementation standards. These differences affect the ability to provide world-wide communications. If voice and data networks can be integrated

into a combined digital network there would be an improvement in network services and significant savings in maintenance cost. Integrated Service Digital Network is the technology being considered to provide this integration. There are many advantages that can be expected when implementing an integrated system; some of this advantages are summarized below.

1. A Rapid Decision - Making Advantage

No other management topic has received as much attention as management and organizational decision making. In the classical theory of management, decision making is often seen as the center of managerial activities, something that engages most of the time of managers.[Ref.1:p.47]. We now know that this is not exactly the case and is an overstatement [Ref.2:p.48]. Decision making is nevertheless one of many management activities. It is one of the areas that information systems have sought most of all to affect.

Using Anthony's categories, decision-making activity in an organization can be divided into three types: strategic, management control, and operational control.[Ref.3:p.45].

a. Strategic Decision Making

It is concerned with deciding on the objectives, resources and policies of the organization. A major issue at this level of decision making is predicting the future of the organization and its environment, and matching the

characteristics of the organization to the environment. This process generally involves a selected group of high-level managers who deal with very complex non-routine problems.

b. Management Control Decision Making

It is principally concerned with how efficiently and effectively resources are utilized and how well operational units are performing. Management control involves close interaction with those who are carrying out the tasks of the organization; it takes place within the context of broad policies and objectives set out by strategic planners, and also involves an intimate knowledge of operational decision making and task completion.

c. Operational Control Decision Making

It is related to decisions about carrying out the specific tasks set forth by strategic planners and management. It involves determining which units in the organization will carry out the task, establishing criteria of completion and resource utilization.

2. An Adequate Information System Scheme

While computer hardware and software are vital elements in information systems, they work efficiently only when information is properly organized. This is achieved when there is a well structured system architecture that combines the sophisticated hardware resources and the technical implementation of the software. Hardware is in the form of

high speed computers, telecommunications, storage, and output devices. Software is to control and administer the hardware But more important is a rethinking of the role of information in the organization. Information must be seen as a resource that should be consciously managed. This idea is new in the history of organizations, which have tended to think of information as a bureaucratic necessity, something of little value, and certainly not something to manage.

Related to this changing conception of information is a changing emphasis in information systems. In the past, a greater emphasis was placed on efficient storage and processing of large, predetermined reports and outputs such as payroll checks, personnel listings and others. Once systems succeeded here, a new emphasis emerged in the late 1970s on widely dispersed access to corporate information by end users often untrained in the use of computers. This new emphasis requires new techniques of file organization.

One of the main purpose of an information system is to provide users with timely, accurate, and relevant information stored in computer files. In organizations such as the Peruvian Air Force, these goals are partially met because of poor file management and inadequate hardware and software. When computer files are poorly managed, they lead to information processing chaos, high cost, poor performance, and little if any flexibility. This occurs despite the use of the most modern hardware and software. There must be conscious

effort to manage the organization's information. The integration will provide the possibility to manage not only the information centralized in one geographical location, but also it allows the effective control of information resources throughout the organization.

C. THE INFORMATION SYSTEMS IN THE PERUVIAN AIR FORCE

The Information System in the Peruvian Air Force can be grouped into four functional areas: Personnel, Operations, Economy, and Materials (supply and maintenance). Each functional area is controlled by a sub system that consists of a number of appropriate applications. These applications were designed to satisfy the specific demands of a particular user organization and were not based on a common conceptual schema. Therefore, the optimal performance of the system could not be realized due to lack of interoperability.

The importance of the integration of the information systems had been appreciated by the Information Center Command, but a solution meeting all the requirements and constrains for integration has not been presented yet. This thesis is intended to present a feasible solution for the integration of the Peruvian Air Force's Information Systems and therefore be able to provide means for the implementation of a distributed system concept.

The peruvian Air Force's information systems face several problems arising from a non-integrated system, and a non-

effective management of information resources. These problems that determine the status-quo of the Peruvian Air Force's information systems are summarized as follows:

1. Complexity

There are many programs and applications, with no one in the organization knowing what they do, what data they use, what documents are needed for their operation, and who is using the data. There is no central directory of data files, data elements, or definitions of data.

2. Data Redundancy

There are three kinds of data redundancy. First, divisions will collect the same information repeatedly from the user. Second, within the same division, many functional areas will collect the same information. Third, the same information will be collected on multiple documents.

3. Data Confusion

The same data element will have different meanings and definitions in different parts of the organization. Simple data elements like the fiscal year, employee identification, can take on different meanings as programmers and analysts work in isolation on different applications.

4. Program-Data Dependence

Every computer program has to describe the location and nature of the data with which it works. These data declarations can be longer than the substantive part of the

program. In a traditional environment, any change in data requires a change in all of the programs that access the data.

5. Costly Program Development

The development of new applications takes more time and money than it would otherwise. Programmers have to write complicated programs, stripping data elements from a variety of files to create new files. New programs require new arrangements of data.

6. Costly Maintenance

A large part of the programming effort involves updating data elements that are scattered throughout hundreds of files. In many instances, applications work with outdated data simply because of the difficulty of making updates.

7. Lack of Flexibility

A traditional system can deliver routine scheduled reports after extensive programming efforts, but it cannot deliver ad hoc reports or respond to unanticipated information requirements in a timely fashion. The information required by ad hoc request is "somewhere in the system" but is too expensive to retrieve. Several programmers would have to work for weeks to put together the required data elements in a new file. Users--in particular, senior management--begin to wonder at this point why they have computers at all.

8. Poor Security and Lack of Privacy

Because there is little control or management of data, access to and dissemination of information are virtually out of control. What limits on access exist tend to be the result of habit and tradition, as well as of the sheer difficulty of finding information.

9. Lack of Data Sharing and Availability

Because pieces of information in different files and different parts of the organization cannot be related to one another, it is virtually impossible for information to be shared or accessed in a timely manner.

D. PERUVIAN AIR FORCE INFORMATION SYSTEMS POLICY

Many milestones had been set by the Information Systems Center to meet the goals that guide the current policy. The decentralization of information had been strongly considered. The assignment of computer equipments in the locations where information is generated has been presented as a project. However none of this milestones have been accomplished yet.

The Peruvian Air Force's information systems policy is divided into three important sections. The first one is to provide support at the operational level of the organization, with effective EDP systems installed in bases, Units, Air Attaches and Supply offices to administer the resources. The second section is to provide support at the staff level of the organization; this will facilitate the planning and

projections for the short and long term objectives. The third section on policy, and perhaps the most important one, is to provide accurate and valuable information to the Air Force Command, to support the decision making process in peace and war times.

However these goals failed to be fully implemented due to the following factors:

- The absence of a the definition on an integrated information system.
- The lack of required economic resources.
- The lack of communication and coordination between the Information System Departments and the Electronic and Communication Development Departments.

In 1985, a project to create a private communications network for the Peruvian Air Force was presented. One alternative considered the use of a domestic satellite (DOMSAT), but this was not implemented because the economical resources were too limited to make a substantial renovation of existing telecommunication structures. A second alternative was presented in March of 1987 by the electronics and communications department, in which the usage of private microwave channels and UHF links were proposed. Once more the economical backing for this project was not enough. Additionally, there was no coordination between the Information Center (CINFA) and the Communications and Electronics Command to pursue the plan. This lack of

coordination led to failure in meeting the information demand and data rate requirements.

III. CURRENT SYSTEM OVERVIEW

A. BACKGROUND

1. Regulations

The Peruvian Air Force's information systems are controlled by the Information Center (CINFA). This department is responsible for promulgating the standards and procedures for the operation of the information resources and equipment, and is also accountable for the development of new applications. It is regulated by the normative document manual, Ordenanza 20-54, that states the goals, responsibilities and the framework for the control of the information system.

2. Peruvian Air Force Information System Maturity

The Nolan six stage model is used as a conceptual tool to help understand the level of maturity that information systems have reached in an organization.[Ref.4:p.233-241]. The model consists of six stages of growth toward maturity. The six stages are initiation, uncontrolled expansion, control and planning, integration of applications, data administration activity, and maturity where applications are complete and match the organizational objectives.

The increasing need to support the information requirements from the dependencies that were not linked to any

of the main hosts created the first wide-spread use of computers outside the data processing areas. Because of the difficulty in computer acquisition, many agencies and departments applied the "back-door" approach to acquire computer support, mainly in the form of PCs. This led to a non-standard approach to solving the information system problem.

The CINFA, which administers the Peruvian Air Force's information systems, has recognized and solved the problems associated with the introduction and management of the information systems. But issues related to the integration have not yet been solved. This seems to place the Peruvian Air Force's information system at the integration of applications phase in the Nolan model.

B. SOFTWARE DESCRIPTION

The software actually in use was developed to satisfy the requirements of the Peruvian Air Force in the late 70's and early 80's. Most of the applications were developed in COBOL INFOS. Currently many problems are emerging due to the ineffective standards for the development of new applications and the maintenance of undocumented systems. These problems consume most of the already scarce human resources. Correcting errors and modifying undocumented systems are daily chores of skillful personnel who otherwise are needed to meet the deadlines of other critical requirements. A new concept for

the system is being developed that will eliminate the problems resulting from nonstandard systems. This new concept is based on the architecture of distributed systems and aims to develop distributed applications under structured standardized programming.

1. System Scheme

The information systems in the Peruvian Air Force are divided into four basic sub-systems in accordance with the structured model approach. The four basic sub-systems are: Personnel, Material (supply and maintenance), Economy, and Operations. They represent the functional groupings of automatization. Figure 1.

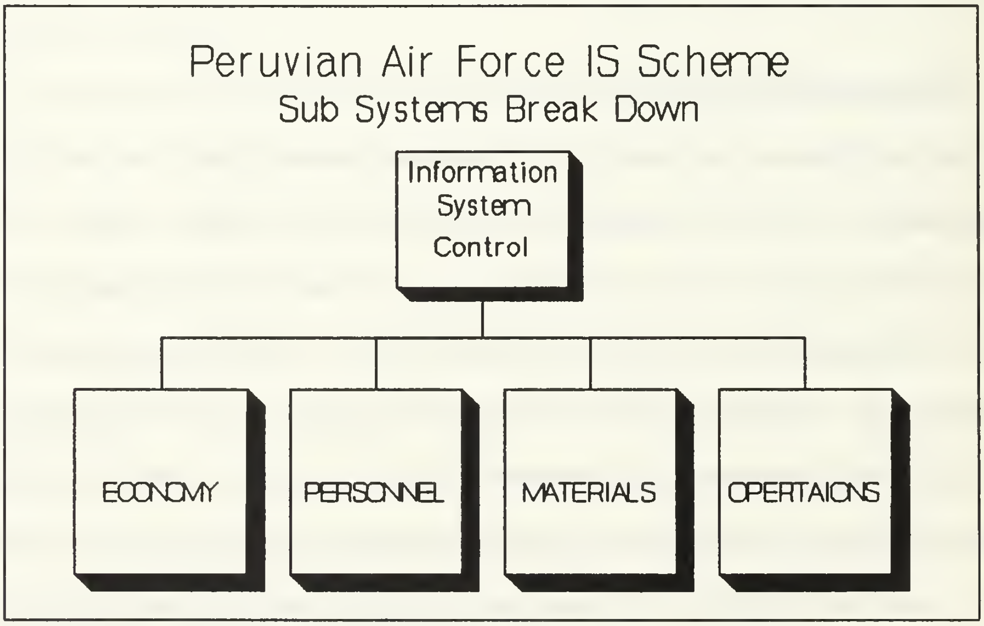


Figure 1. System Structure.

2. Current Applications

The current IS design was based on the functional structure of the system. Its design objective was automatization at the operational level by providing an electronic data processing system. According to Anthony's scheme of organization, this approach relieves only the data processing requirements at the lower level of the organization. EDP changes the manual operations to the applications solved by a computer based system. The support for the operational control level and the strategic planning level was not an issue that needed to be addressed.

The functional approach of the system and its hierarchical structure limitations created many problems in redundancy, inconsistency and duplicity of data and applications. Many factors contributed to this situation such as non-standard approach for the development and the lack of communication between computers.

The Applications currently used in the information systems interact with the four main subsystems to solve and satisfy their information needs. The interaction occurs not only with a specific subsystem but also across other subsystems. Figure 2.

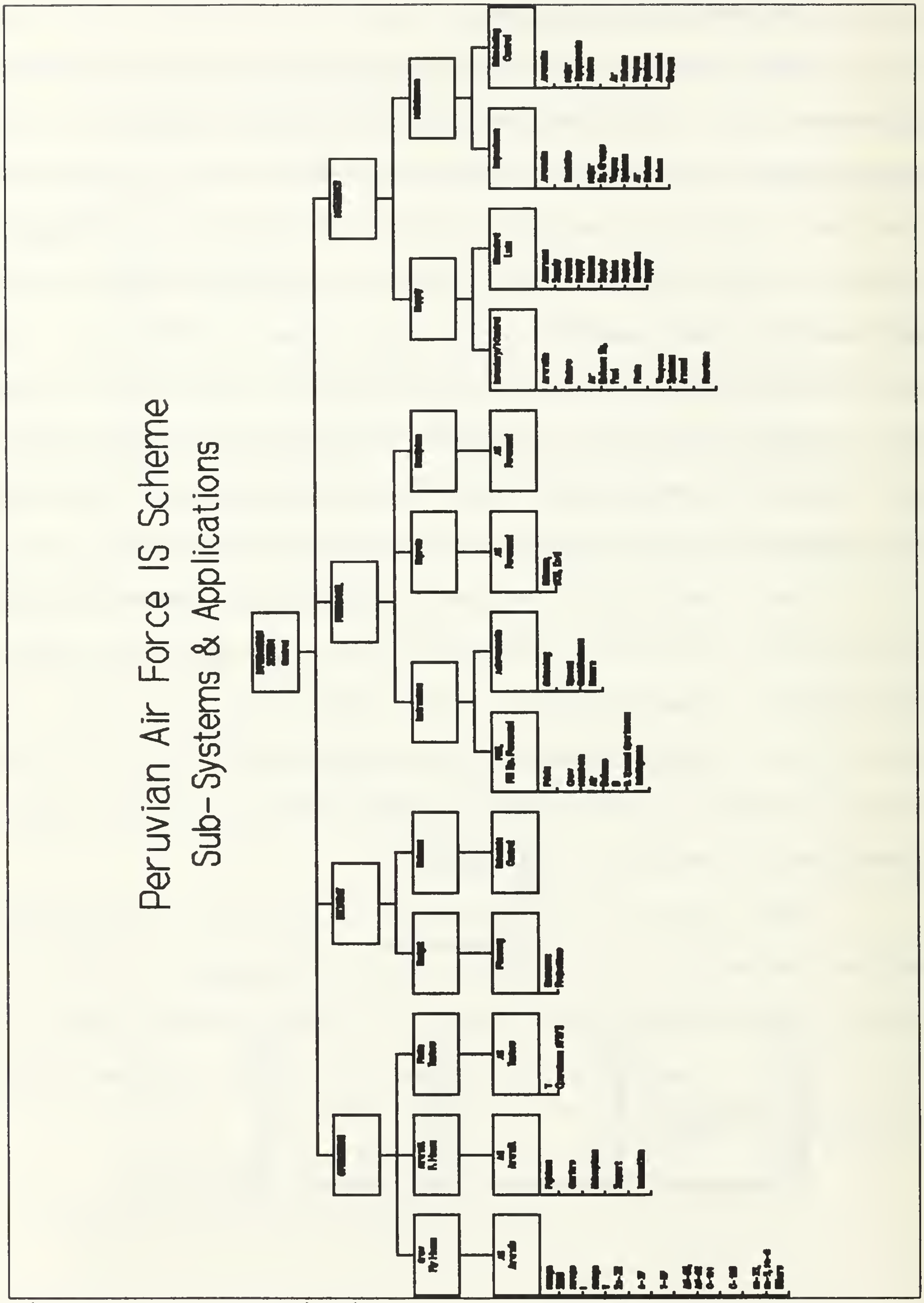


Figure 2. IS Description.

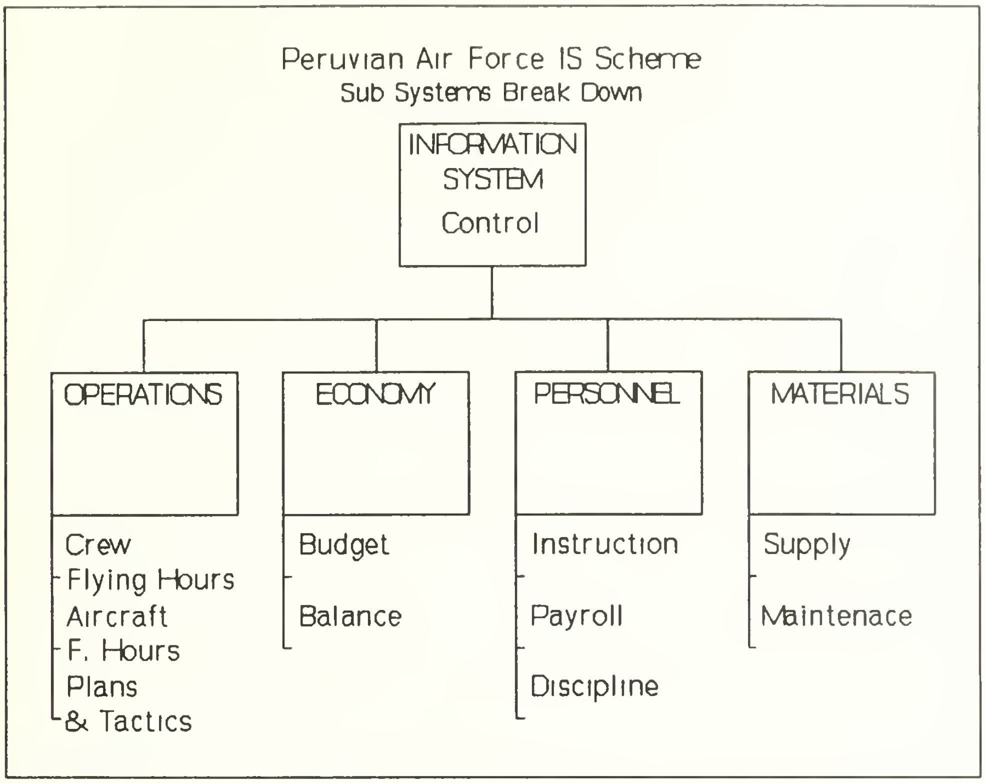


Figure 3. IS Break Design

The information systems design was based on the functional nature of the needs in the AF. The first interest was to provide an effective support at the operational level to improve control. The second objective was to provide an advanced tool to collect data from the different areas of the operational level and transform this data into relevant information for decision making.

There is a close interaction among the elements of the system to perform the tasks and reports required. The following describes the subsystems, how they work and the scope of each:

a. Operations Subsystem

The operations subsystem is the part of the IS responsible for the control and scheduling of all the operations and tactics that involve the entities of crew members and aircraft. To do so, it interacts with two other subsystems, Personnel and Materials, in order to check the ability and availability of the entities involve, Figure 4. A restricted application for the planning and tactics modules is used in case of war, tackling the different theaters of operations that could involve the use of the Peruvian Air Force men and resources.

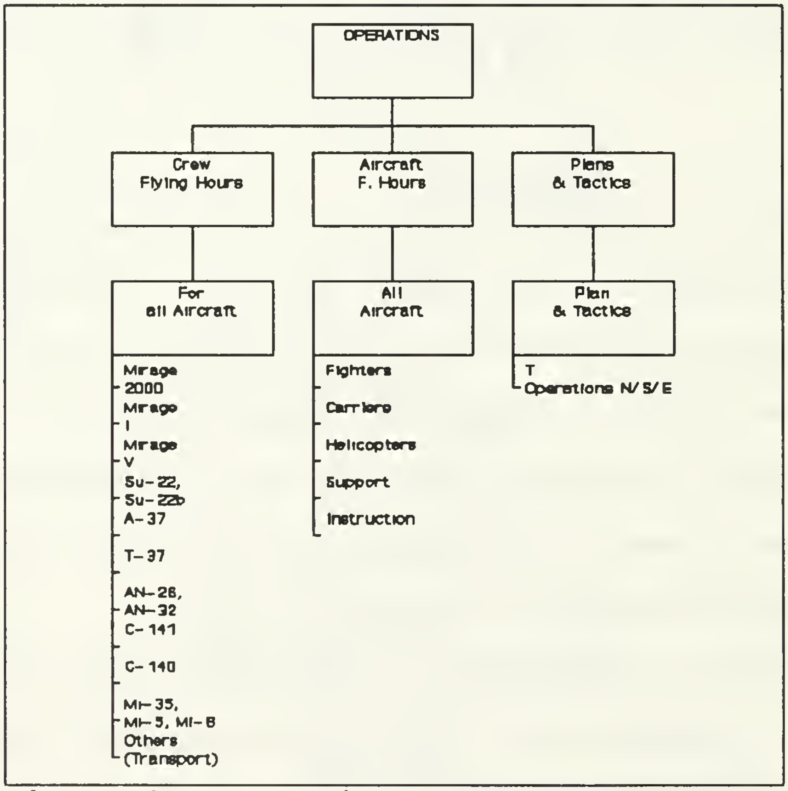


Figure 4. Operations Subsystem.

b. Economy Subsystem

This subsystem provides support to the economical entity in the institution, see Figure 5. It controls the economical resources, performs analysis on expenditures, and provides an updated balance status to guide the economical approach of the institution. It interacts with the Personnel subsystem to perform payroll and with the Materials subsystem to provide funds for new acquisitions, inventory control and maintenance.

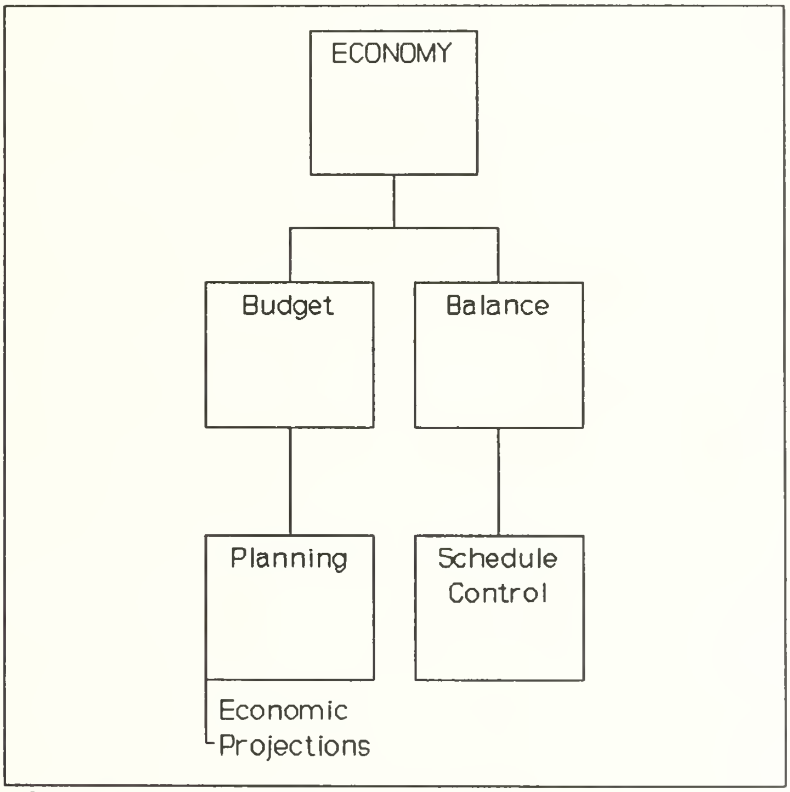


Figure 5. Economy Subsystem.

c. *Personnel Subsystem*

This subsystem controls all the data pertaining to personnel in the Peruvian Air Force. It is divided into three parts that satisfy the information needs in the different areas. The first area of applications is instruction, where the achievements of each member of the institution are recorded. This include all the data on the personnel entity. The second part interacts with the Economy subsystem to perform payroll applications, and the third part is related to all qualifications and characteristics of each individual of the Peruvian Air Force, see Figure 6.

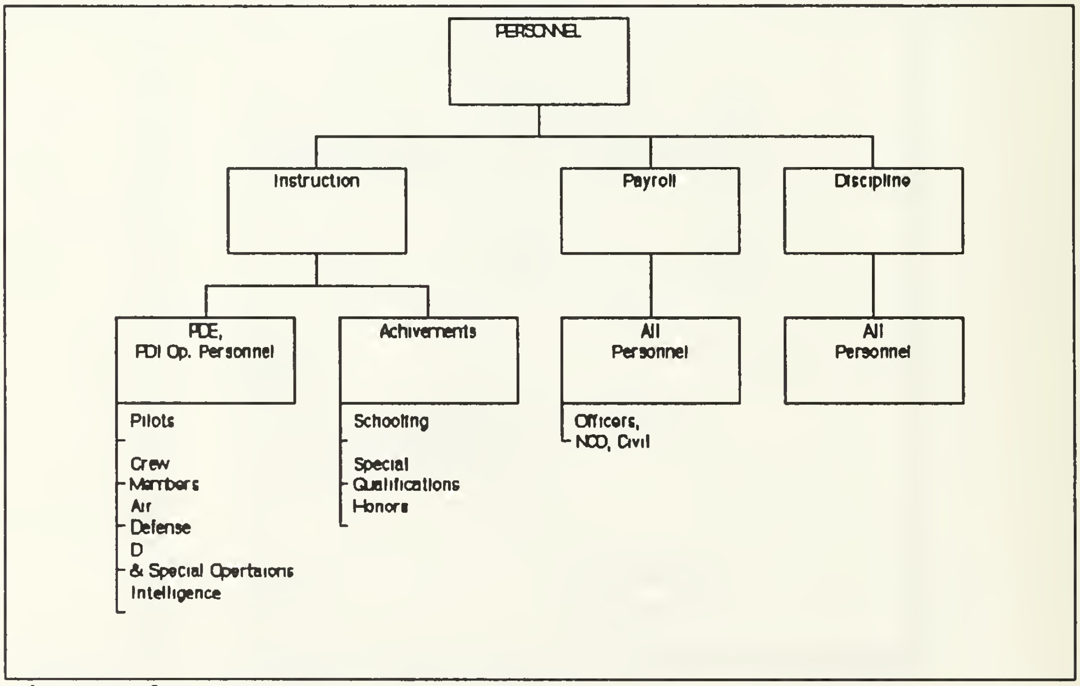


Figure 6. Personnel Subsystem.

d. Materials Subsystem

This subsystem is concerned with two important areas: Supply and Maintenance. The first one deals with inventory control of parts and storage of materials. It also stores the codification requirements given by the standards' lists from the different suppliers of the Peruvian Air Force. The second area deals with the maintenance, schedules and inspections of the aircraft. It heavily interacts with the Operations subsystem in order to maintain relationships between the availability of aircraft and the missions scheduled. Figure 7.

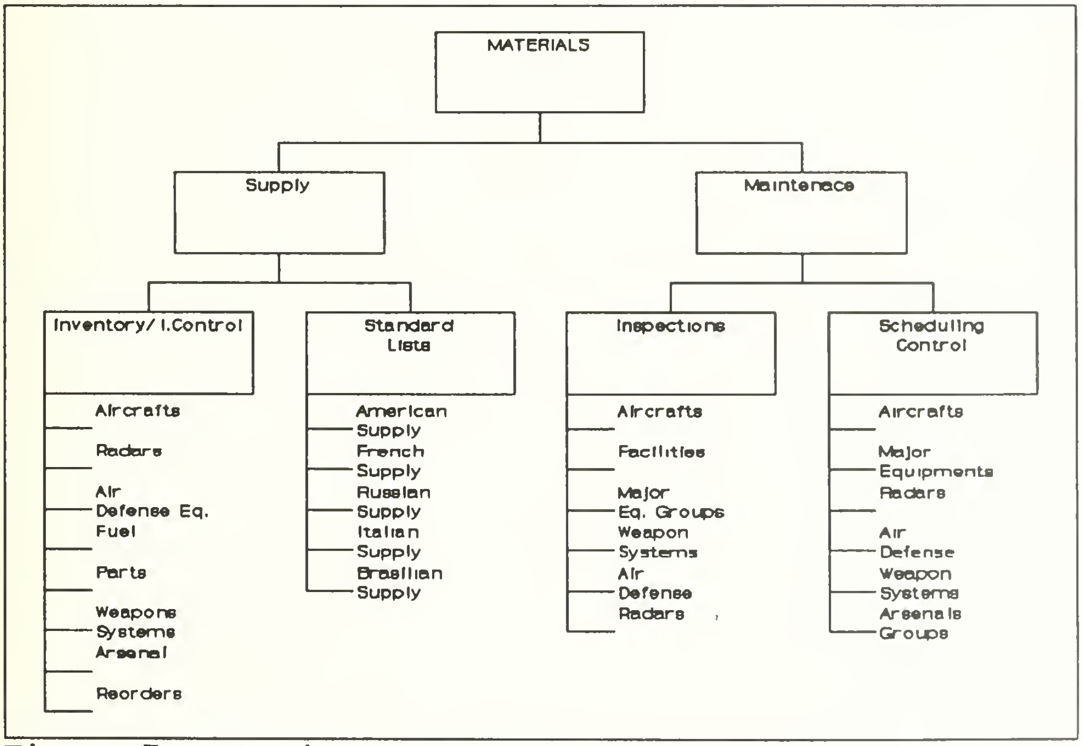


Figure 7. Materials Subsystem.

C. HARDWARE DESCRIPTION

The automation at the operational level was the first concern at the initial stages of the IS for the Information Center (CINFA) in the Peruvian Air Force. The increasing need for computing systems to support the chores in the different dependencies created a wide-spread use of computers outside the EDP areas. The uncontrolled acquisition of computer support led to a non-standard approach to solving the information system problems.

1. Vendors

The main vendor of computer equipments and supplies in the Peruvian Air Force is Data General Corporation. The main computers used are ECLIPSE MV-15000, MV-4000, MV-2000, and desk-top DG-30. Other equipments are provided by IBM vendors and CONVERGENT.

The computer center (CINFA) has chosen Data General as its main provider based on the technical support this vendor gives in Peru and the size of the computers satisfying their needs. The systems are currently overloaded by redundancy of data and applications, which is a consequence of the lack of an integrated means of communication among the different sites of the computer equipments available. Table 1. shows the hardware currently in use in the Peruvian Air Force Information System architecture.

TABLE 1. COMPUTER EQUIPMENT DISTRIBUTION.

UNIT	**PROCESSOR**	**USERS**	**ZONE**	**LOCATION**
CINFA	MV-15000 DATA GENERAL	EMGRA INSPECT CODEI COMOP COMAT COPER CODEF DIGIN DIGEC SEIN SEING ODOME BIENESTAR G.COM.ELECT	I I I I I I I I I I I I I I	HEADQUARTERS LIMA
DIGEC	DG-30 DATA G. IMB-AT	PLANS PROJECTS	I I	HQ. LIMA HQ. LIMA
EMGRA	IBM-XT	STAFF	I	HQ. LIMA
ALAR 2	MV-4000 DATA GENERAL	GRU-8 GRU-3 METEREOLOGY	I I I	CALLAO LIMA
SEBAT	MV-15000 DATA GENERAL	SEMAG SECOM EOFAP	I I I	LAS PALMAS LIMA
SEMAN	MV-15000 DATA GENERAL	ESOFAP CONTROL	I I	LAS PALMAS LIMA
EOFAP	IBM-AT 6 IBM-XT	GRUDI CADETS	I I	LAS PALMAS LIMA
HCDA	2 IBM-AT 3 IBM-XT	CONTROL RECORDS	I I	MIRAFLORES LIMA
ESFAP	DG-30 DATA G.	RECORDS	I	MRF. LIMA
DIGAF	CONVERGENT	ALL SYSTEMS	I	L.P. LIMA
GRU-6	DG-30 DATA G.	ALL SYSTEMS	III	CHICLAYO
GRU-11	DG-30 DATA G.	ALL SYSTEMS	III	TALARA

UNIT	PROCESSOR	USERS	ZONE	LOCATION
GRU-7	DG-30 DATA G.	ALL SYSTEMS	III	PIURA
GRU-42	DG-30 DATA G.	ALL SYSTEMS	IV	IQUITOS
GRU-4	MV-15000	ALL SYSTEMS	II	AREQUIPA L.J
GRU-9	DG-30 DATA G.	ALL SYSTEMS	II	PISCO-ICA
GRUFE	IBM-C-10	ALL SYSTEMS	II	AREQUIPA VT.
AGRARS	IBM-AT	CONTROL	V	OVERSEAS

2. Computer Equipment Description

The computer equipments are configured around medium sized computers. The amount of information to be processed is relatively small compared to normal size systems in the U.S. Medium- and small-sized computers can satisfy the information requirements in the Peruvian Air Force and also fall within the budget constrains imposed by the Command. Many of the computer-based systems are overloaded as a consequence of an inappropriate system architecture and non-integration that implies the replication of the database and applications in each of the computer sites.

Table 2. describes the memory and storage capacity of the computers, their geographical location in relation to the zone of coverage, and the unit or air base that holds it.

TABLE 2. COMPUTER EQUIPMENT DESCRIPTION.

COMPUTER	UNIT	MEMORY C.	STORAGE C.	ZONE
MV-15000 D. GENERAL	CINFA	16 MB	2 Dks 354 MB 1 Dks 322 MB 2 Tape U. 800/1600 BPI	I
MV-15000 D. GENERAL	SEMAN	8 MB	2 Dks 354 MB 2 Dks 322 MB 1 Tape U. 800/1600 BPI	I
MV-15000 D. GENERAL	SEBAT	8 MB	1 Dks 662 MB 2 Dks 354 MB 2 Tape U. 800/1600 BPI	I
MV-15000 D. GENERAL	GRU-4	8 MB	2 Dks 354 MB 1 Tape U. 800/1600 BPI	II
MV-4000 D. GENERAL	ALAR-2	6 MB	2 Dks 354 MB 1 Dks 322 MB 2 Tape U. 800/1600	I
DG-30 D. GENERAL	DIGEC	1.5 MB	1 Dks 71 MB 1 Low Den. Dkt.	I
IBM-AT	DIGEC	512 KB	1 Low Den. Dkt.	I
DG-30 D. GENERAL	ESFAP	1 MB	2 Dks 15 MB 1 Low Den. Dkt.	I
DG-30 D. GENERAL	GRU-42	1 MB	2 Dks 71 MB 1 Low Den. Dkt.	IV
DG-30 D. GENERAL	GRU-6	1 MB	1 Dks 71 MB 1 Low Den. Dkt.	III
DG-30 D. GENERAL	GRU-7	512 KB	1 Dks 38 MB 1 Low Den. Dkt.	III
DG-30 D. GENERAL	GRU-9	512 KB	1 Dks 38 MB 1 Low Den. Dkt.	II
DG-30 D. GENERAL	GRU-11	1 MB	1 Dks 71 MB 1 Low Den. Dkt.	III

IBM-AT	EMGRA	512 KB	1 Dks 20 MB 1 Low Den. Dkt.	I
2 IBM-AT 6 IBM-XT	EOFAP GRUDI EOFAP GRUDI	512 KB 256 KB	2 Dks 20 MB 2 Low Den. Dkt. 1 Low Den. Dkt.	I
2 IBM-AT 3 IBM-XT	HOSPI HOSPI	512 KB 512 KB	2 Dks 20 MB 2 Low Den. Dkt. 2 Low Den. Dkt.	I
CONVERGENT	DIGAF	2 MB	1 Dks 71 MB 1 Low Den. Dkt.	I

3. Geographical Coverage Distribution

The computer equipments in the Peruvian Air Force's information systems are dispersed at the air bases and air wings nationwide. There is a tendency to centralize most of the equipments in Lima, within the Headquarters and other dependencies in the metropolitan area of the Air Force. Based on this geographical distribution, there has been a division by zones. Each zone represents the areas that are served by a particular computer equipment. There are five zones in the distribution, covering the nation. There are international links with the air attaches.

Figure 8. represents the geographical location of the equipments and the grouping based on the zone distribution from the nation wide perspective.

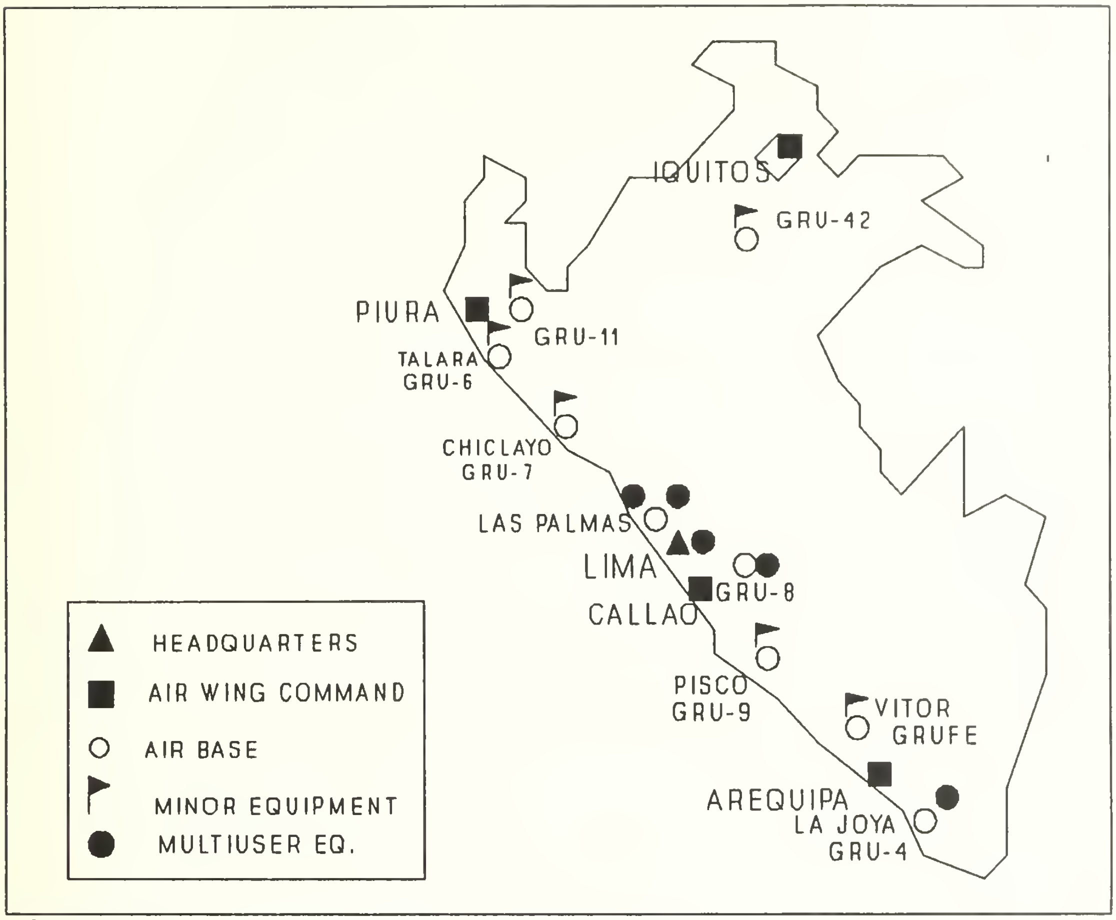


Figure 8. Geographical Distribution.

4. Zones of Distribution

Based on the geographical location of computer, there are distribution zones, each of which covers the bases that are under the command of a particular Air Wing. The administration entity resides inside the domain of the Air Wing that they belong to. Most of the larger equipments are in the metropolitan area of Lima, and the centralize entity is located at Headquarters under the direction of the Information Center CINFA. Figure 9.

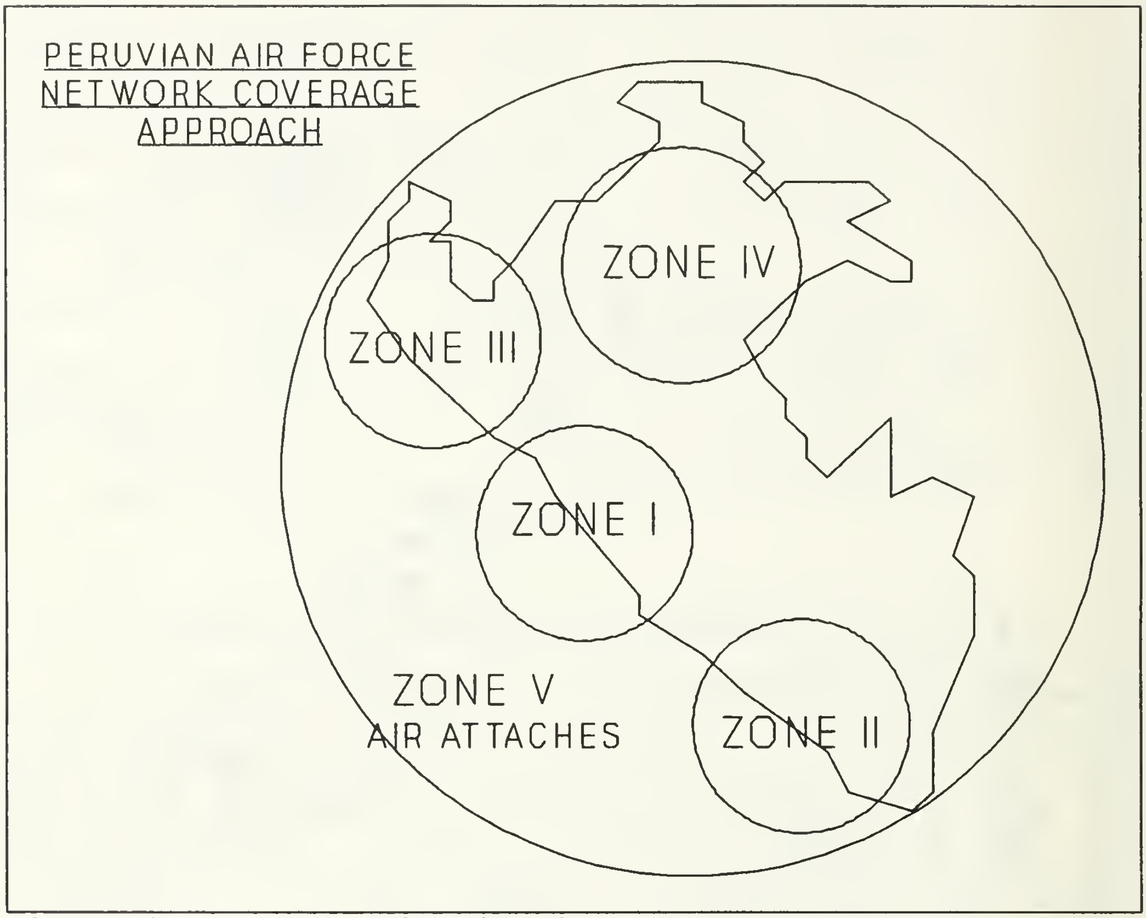


Figure 9. Zones of Distribution.

D. CURRENT NETWORK ARCHITECTURES

There is no dominant network architecture currently in use. However in minor dependencies, as in the case of the Air Force Academy, there are some network capabilities. But they are not fully implemented due to the lack of support, maintenance and knowledge on their operability; therefore they are not considered in this thesis as a valid network architecture.

E. DATA PROCESS DEMAND

To design the integrated system, it is important to determine the data rate that the communication media needs to meet. To do so, this section describes the data process demand for each computer system installed throughout the country.

The data demand information was given on a daily basis. This represents a constraint that needed to be addressed. However the information available is enough to calculate a frequency transmission load in each computer system, the proportion of data process demand in each sub-system and the aggregate total for each computer system. All this will represent the data rate requirement for each computer system site.

1. Data Process Demand Distribution

This section describes the load of data process demand currently required by each computer system implemented. The breakdown is based on the four sub-systems of the IS. Some of the data process demand was given for certain applications. Since each application belongs to a specific sub-system, the total data demand of the sub-system was computed.

The following figures represent the data process demand. In these figures data process demand is given for each of the sub-systems, and for each computer system installed.

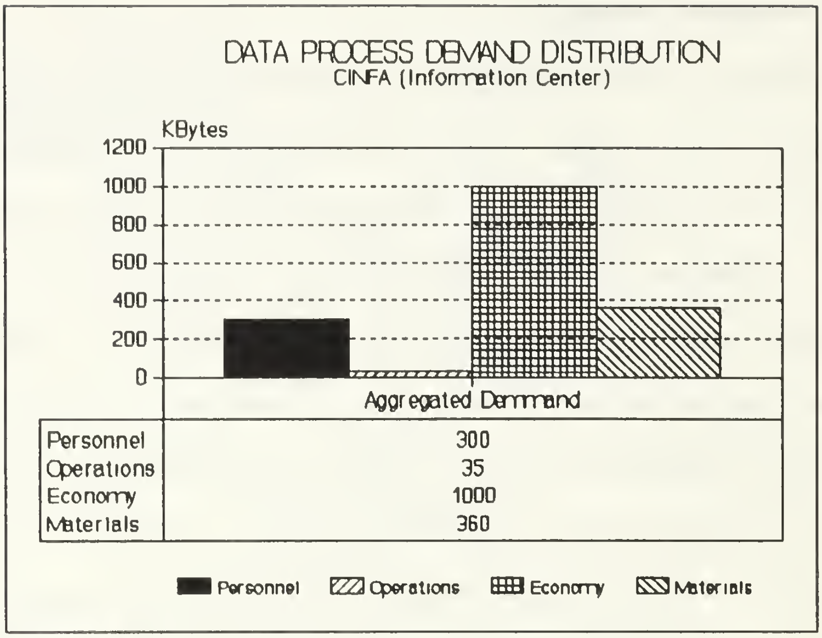


Figure 10. CINFA.

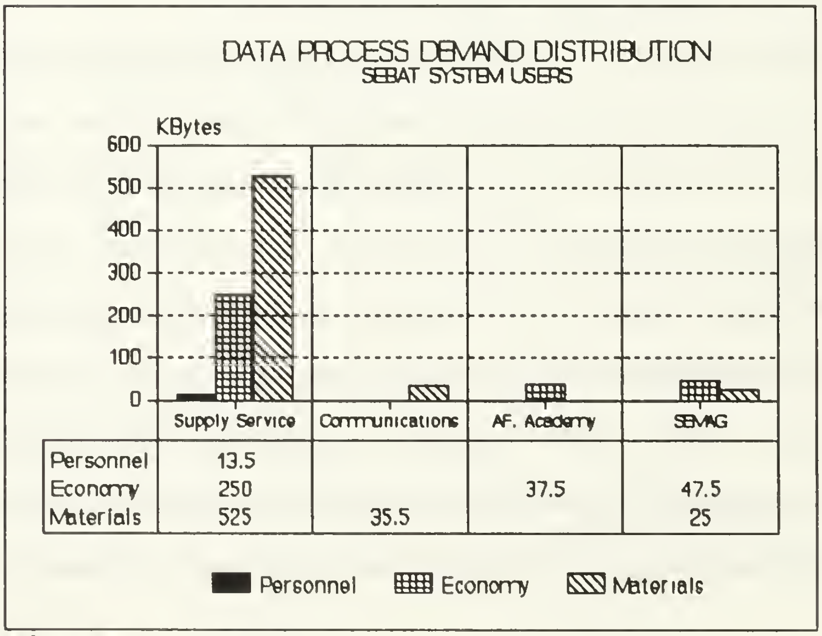


Figure 11. SEBAT.

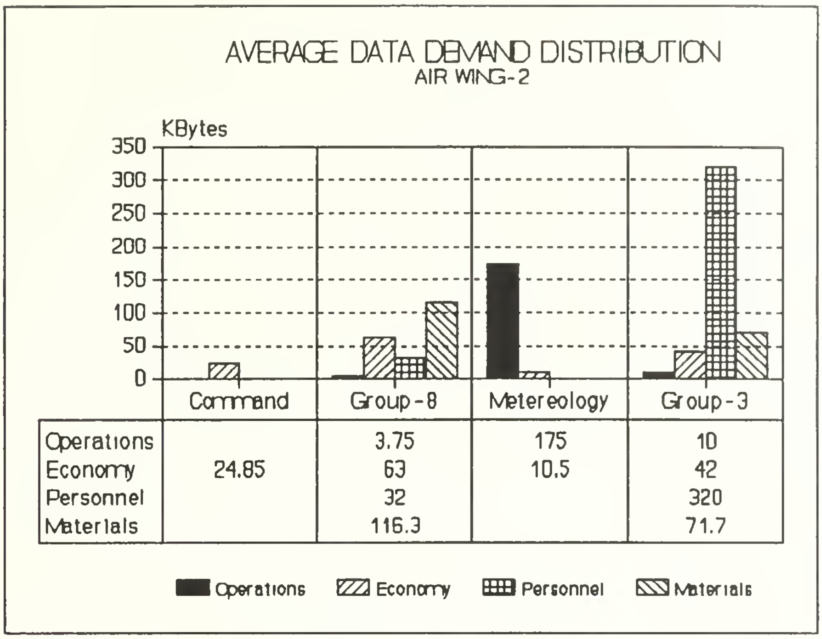


Figure 12. AIR-WING 2.

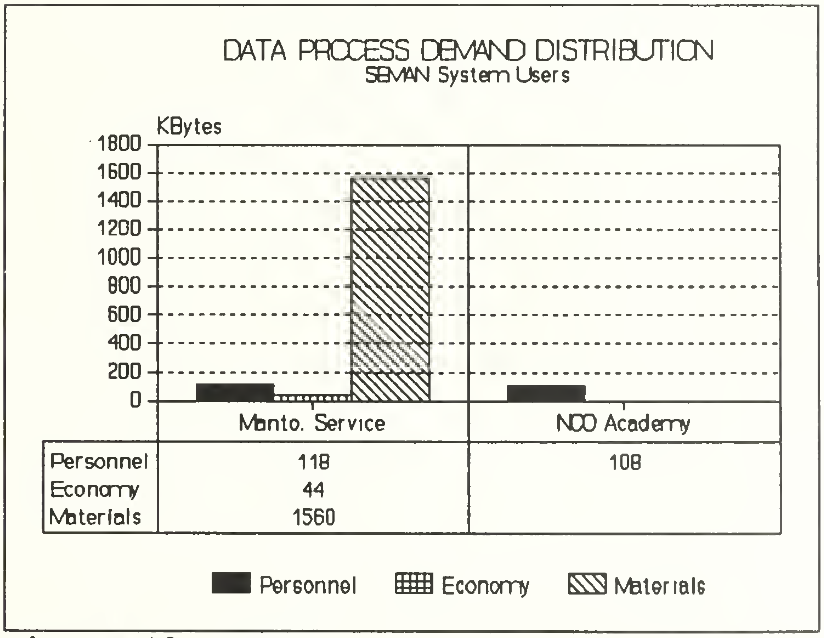


Figure 13. SEMAN.

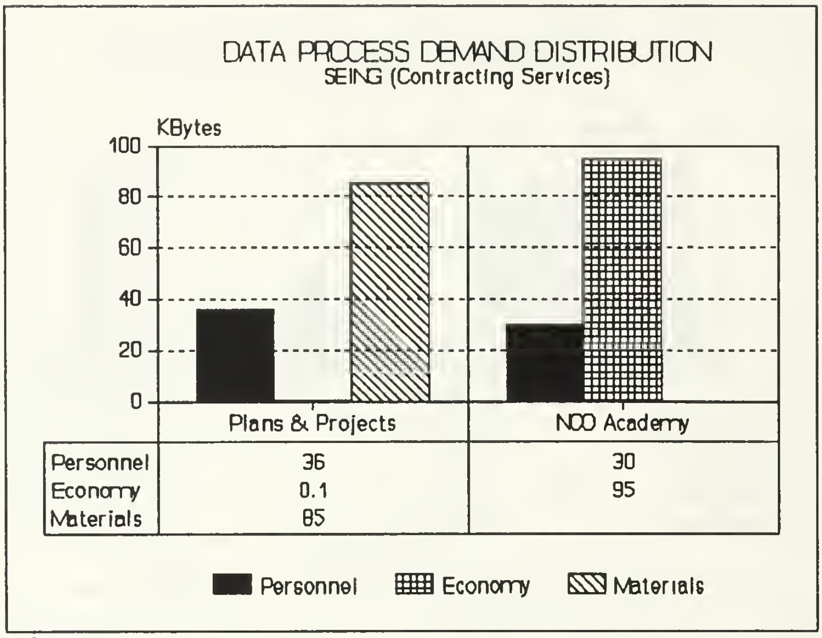


Figure 14. SEING.

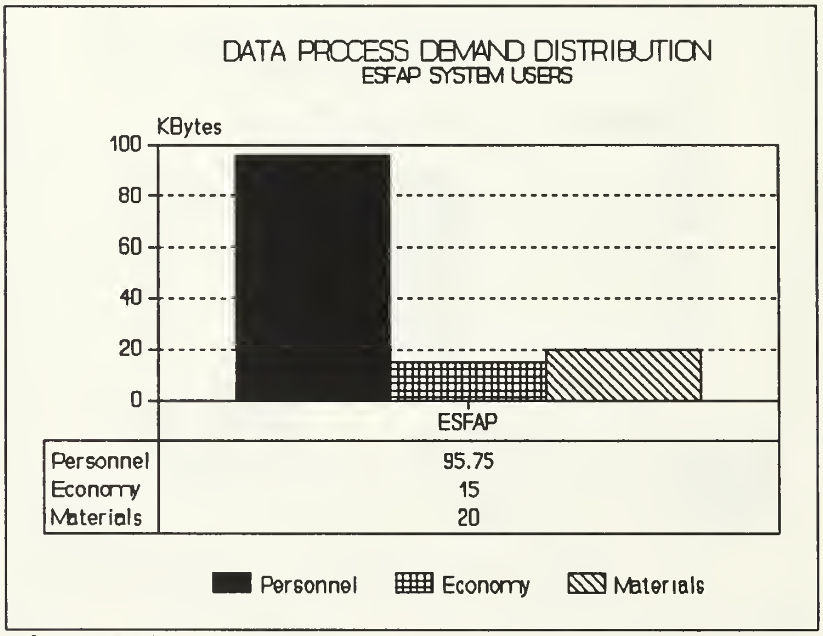


Figure 15. ESFAP.

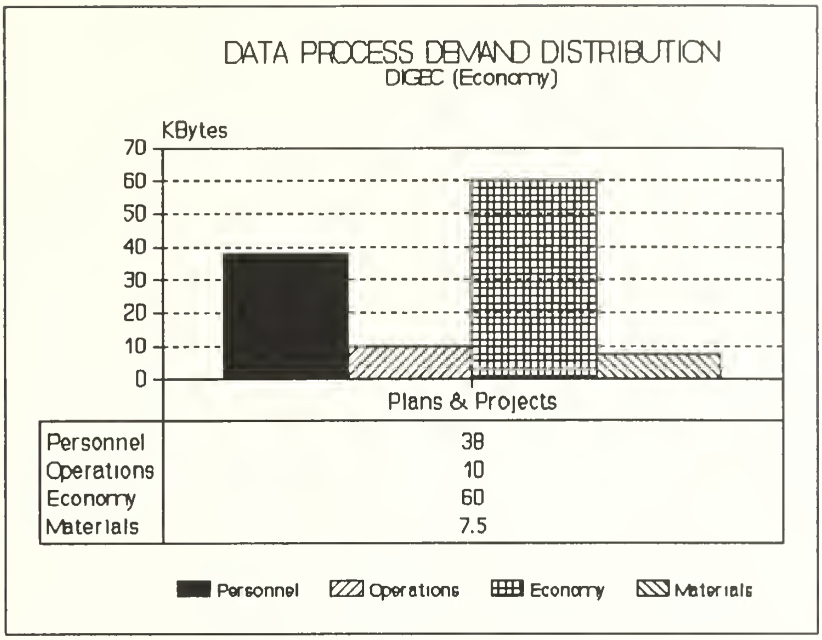


Figure 16. DIGEC.

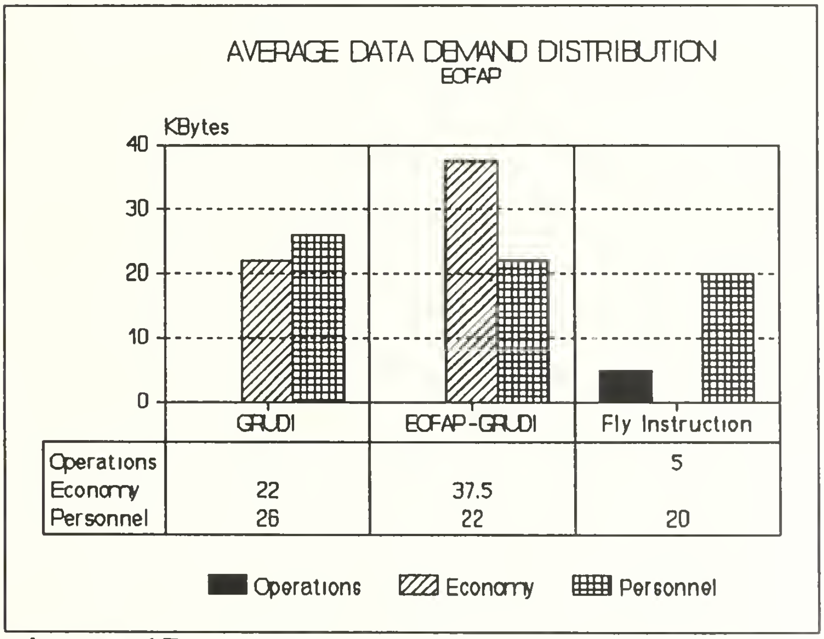


Figure 17. EOFAP.

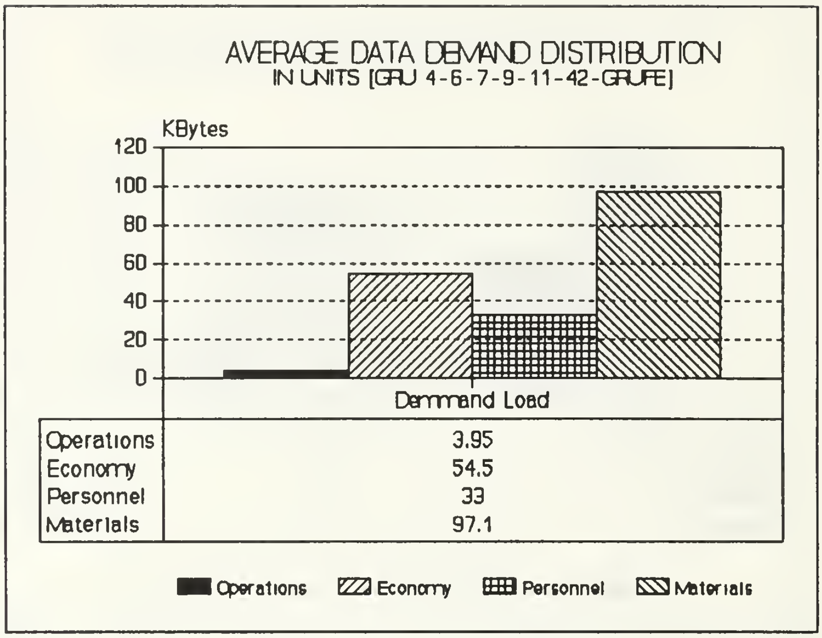


Figure 18. Average Unit Demand.

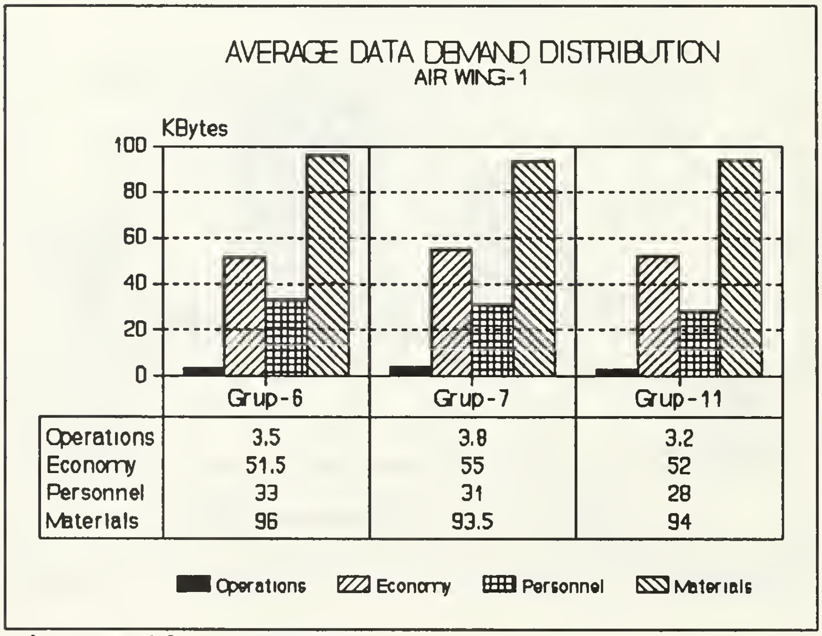


Figure 19. AIR-WING 1.

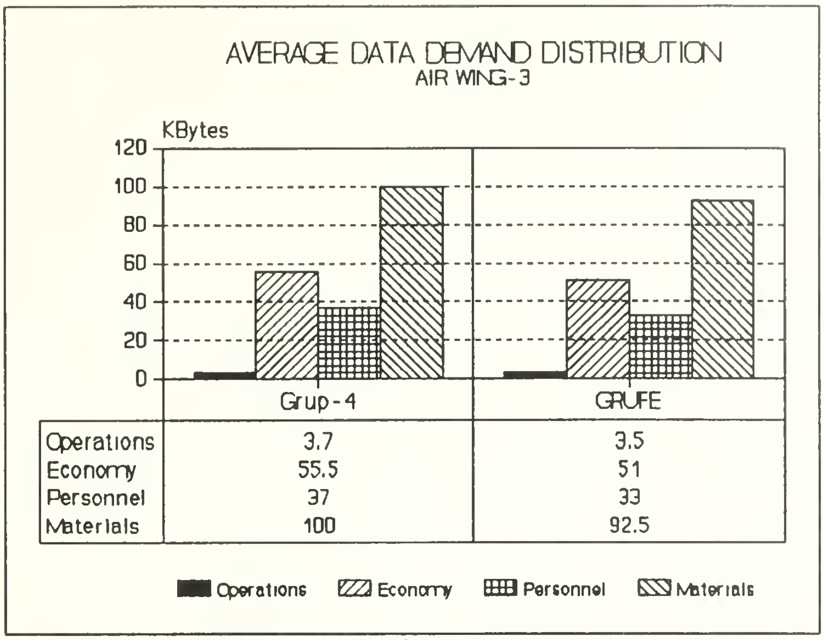


Figure 20. AIR-WING 3.

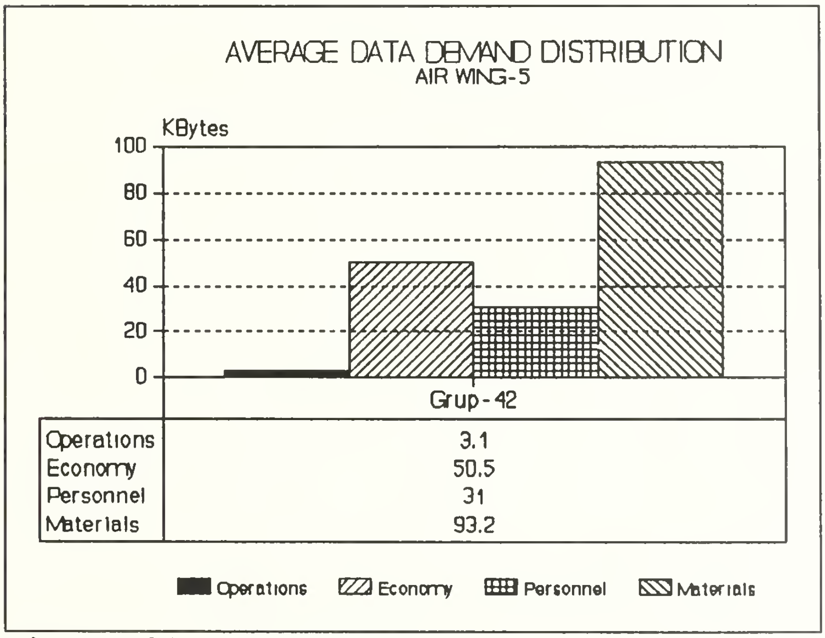


Figure 21. AIR-WING 5.

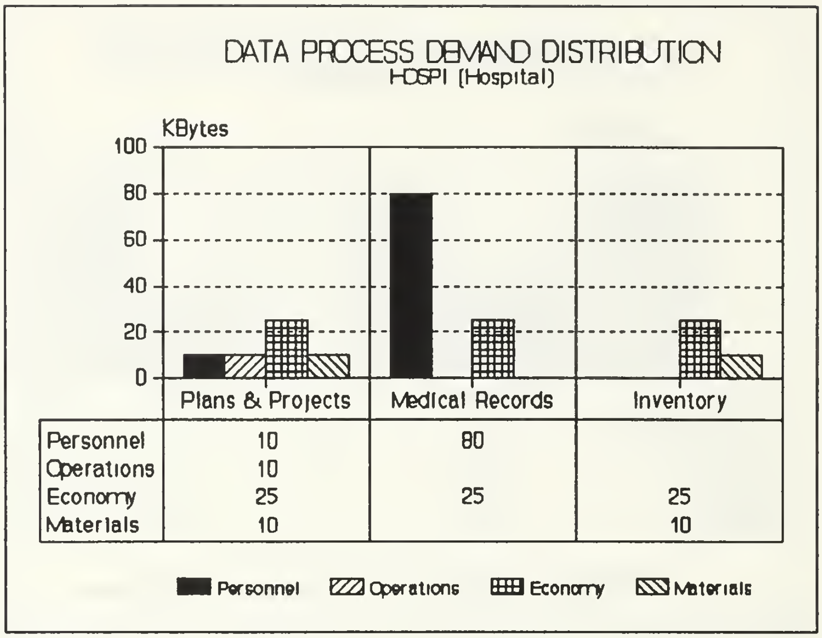


Figure 22. HOSPI.

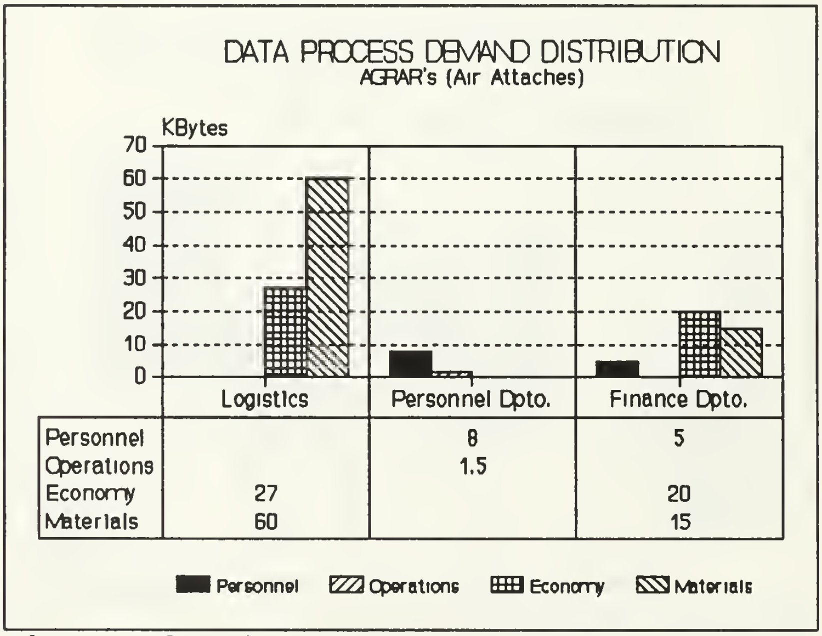


Figure 23. Air Attaches.

2. Message Demand Frequency

This section shows the frequency message load that each computer system supports. It is broken down by subsystems. This breakdown indicates which users are more likely to use certain sub-system in the IS. This does not determine the data rate required in the communication lines, however. By combining both frequency and data process demand we can determine the data load required to link each computer system.

Figure 24 represents the daily message frequency by each sub-systems. Figure 25 gives the total daily message frequency by computer system.

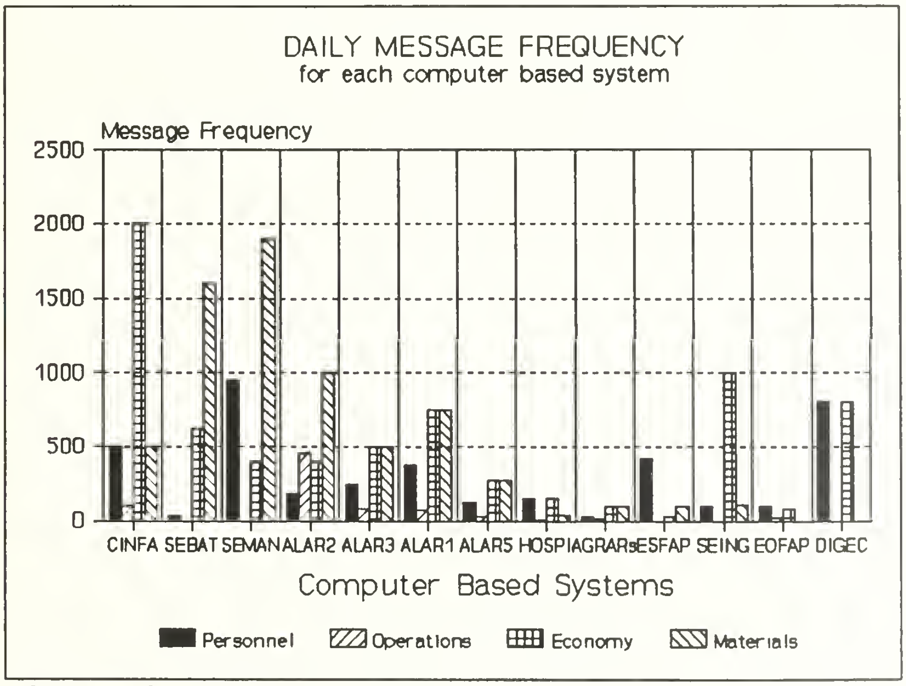
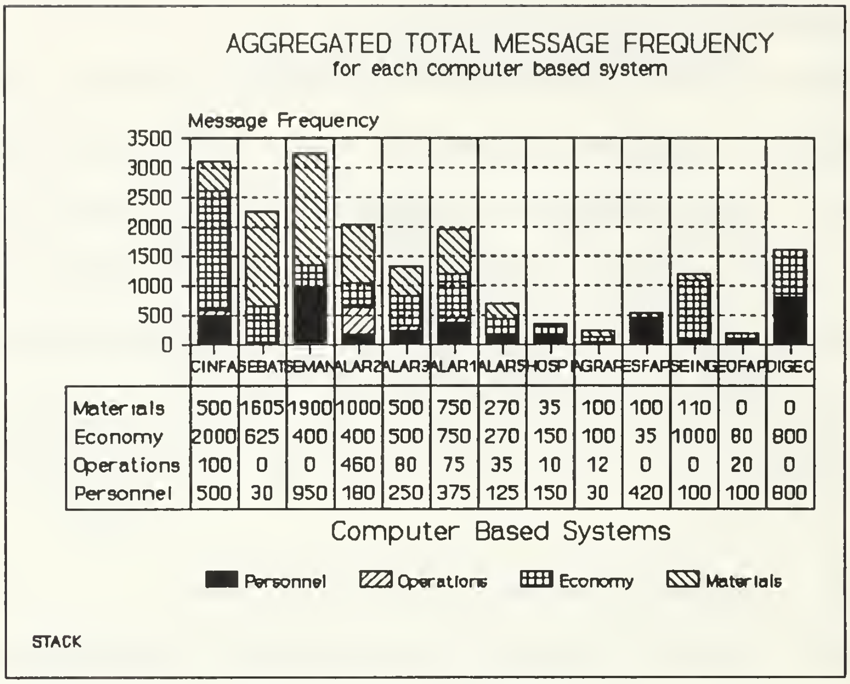


Figure 24. Message Frequency.



	CINFA	SEBAT	SEMAN	ALAR2	ALAR3	ALAR1	ALAR5	HOSP	AGRAF	ESFAP	SEING	EOFAP	DIGEC
Materials	500	1605	1900	1000	500	750	270	35	100	100	110	0	0
Economy	2000	625	400	400	500	750	270	150	100	35	1000	80	800
Operations	100	0	0	460	80	75	35	10	12	0	0	20	0
Personnel	500	30	950	180	250	375	125	150	30	420	100	100	800

Figure 25. Aggregated Frequency.

3. Total Data Process Demand

The requirements of data process demand have been described based on the distribution of the computer systems throughout the country. This section condenses all this information to determine the needs of data processing and message frequency. The overall outcome of this analysis is to establish the requirement for the data rates needed in each of the communication channels, and therefore to allow the linkage of the entire IS.

Table 3. shows the aggregate data process demand and the aggregate daily message frequency.

TABLE 3. DATA DEMAND AND FREQUENCY TOTALS.

COMPUTER SYSTEM	**AGGREGATE DATA PROCESS DEMAND [KB]**	**AGGREGATE MESSAGE FREQUENCY**
DIGEC	115.50	1600
ESFAP	130.75	555
EOFAP	132.50	242
ATTACHES	136.50	242
WING-5	177.70	700
AV. UNIT	185.50	650
HOSPI	195.00	345
DIGAF	200.00	700
SEING	246.10	1210
WING-3	376.20	1330
WING-1	544.50	1950
WING-2	395.00	2040
SEBAT	544.50	2260
CINFA	1695.00	3100
SEMAN	1830.00	3250

IV. INTEGRATION DESIGN

Since the main vendor for computers for the Peruvian Air Force information systems is Data General, we shall discuss their approach for connectivity and interoperability. This discussion is based on the interviews with their representatives and the documentation provided for this purpose listed in the reference list.

A. CONNECTIVITY

Providing connectivity means not only adapting to changing technologies with new products but also allowing users to integrate those new products with their existing equipments and application bases.

Data General's compatibility with IBM communication and networking products make it easy to plug the ECLIPSE MV/Family computers into an IBM environment. Data General provides the IBM and multivendor connectivity through adherence to industry and *de facto* standards such as SNA, ETHERNET, NetBios, LU 6.2, X.25, X.400, TCP/IP, ONC/NFS, IEEE 802.5, ISDN, and the Open Systems Interconnected (OSI) model.[Ref.5:p.10].

The ability to link PCs and workstations spread throughout organizations is an important feature of the ECLIPSE MV/Family. Data General's Personal Computer*Integration (DG/PC*I) unites PCs, MV/Family server systems, and mainframes

into a single system for distributed operations. Data General's DAA (Distributed Application Architecture) OPEN LAN Products suite, which gives users the freedom to choose the LAN best suited to their particular applications and environments, demonstrates this facility. Data General provides also the capability for ECLIPSE MV/Family and UNIX systems to interoperate at the level comparable to the IBM communications and networking products.

B. INTEROPERABILITY

1. Data General MV/Family Interoperability

This company has been a pioneer in developing successive generations of computers that work with each other by supporting the same operating system. From AOS to AOS/VS to AOS/VS II. ECLIPSE MV/Family computers introduced ten years ago are compatible with the latest systems. Upgrading from one ECLIPSE MV/Family system to another in many cases is as simple as swapping a processor board or adding one, with no software modifications required.

Data General has also been an industry leader in developing communications links to IBM systems and to those from other vendors.

2. Strategy for Interoperability

At some point in time, every organization has been or will become a "system integrator", one of the hottest buzzwords in computing today. Systems integrator weave

together pieces of technological puzzle to give an organization the best solution to do the job. The goal is to place computing at the convenience of the user, with applications and data distributed optimally throughout the network.

This type of interoperability is allowed by the Data General's Distributed Applications Architecture (DAA). Simply defined, interoperability is the ability of all system elements to exchange information between equipments from the same vendor or a collection of vendors.[Ref.6:p.7].

3. Interoperability Benefits

a. *Investment Protection*

The ability to interoperate with other vendors lets users hold value in their investments in existing and new MV/Family systems, applications, and peripherals, even if they intend to move to other systems in the future.

b. *Freedom of Choice.*

There is a way in which users can take advantage of the best of MV/Family and the other vendors platforms, and expand the power and versatility of each of them.

c. *Access to More Solutions*

The ability to integrate MV/Family and other vendors systems, provides users with a greatly expanded portfolio of solutions to choose from when considering new applications.

d. *Increased Productivity*

Interoperability within a product line or across product lines ultimately can provide one unified work environment where everyone shares the same valuable resources and information. This greater level of access will not only help people become more productive but will also give them tools for making better decisions.

4. Levels of Interoperability

a. *Media Interchange*

Data General supports two tape drives (9-track media, QIC 150-MB cartridge) and two media format types (CPIO and TAR) to accomplish media interchange between MV/Family and other UNIX systems. As a result, users can move data from one system to another without any direct network connections.

b. *Terminal Connectivity*

Data General's strategy is to provide a wide range of options for terminal emulation and connectivity, such that no matter what type of terminal, PC, or workstation a user has, he or she will be able to easily access both AOS/VS and UNIX applications with the maximum possible functionality.

c. *File Transfer*

The File Transfer Protocol (FTP) running on top of TCP/IP allows a remote user to exchange an entire file from AOS/VS servers to UNIX workstations, or vice versa.

d. File Sharing

Supporting the sharing of files among systems, new applications can be written to take advantage of Data General's equipments and other open UNIX systems while sharing data with existing AOS/VS II applications_thus preserving a customer's investment in MV/Family hardware and applications.

e. Remote Services

The real advantage is that customers can share resources (printers, tape drives, etc.) between the systems. In addition, users benefit from increased configuration flexibility, investment protection, and increased productivity through using a common user interface that can be tailored to match the local environment.

f. Network Connectivity

Data General's strategy provides a set of solutions which allow AOS/VS and open UNIX systems users to transparently access and share applications, information, and resources. The approach implements industry and the protocol standards where available including TCP/IP, ISO, Novell, PC*I, and IBM's SNA and Bisynchronous protocols, and supports a wide range of local area networks including thin ETHERNET, ETHERNET, and Token Ring, thereby maximizing a user's freedom of choice.

g. Electronic Mail

Using TCP/IP-based Simple Mail Transfer Protocol (SMTP) with Data General's CEO MAIL product allows users on MV/Family systems to exchange electronic mail messages and documents. This facility gives DG users access to the entire range of electronic mail connections available from CEO software on MV/Family systems.

Today's increasingly competitive and global business environment is rapidly moving computing towards a heterogeneous, client/server-based, enterprise-wide model. This is a model where client Pcs and workstations are connected via LAN or WAN to servers. The server-ECLIPSE systems provide file, database, compute, and office automation (such as mail, time management and filing) services. To gain a competitive advantage in this environment, organizations are taking increasing economic control over information management and are demanding greater participation in and use of corporate-wide information, resources, and communications. They want systems-technology vendors such as Data General to deliver platforms that are stable, and that also have the flexibility to take advantage of the latest technology, and still protect their software investment.

C. INTERCONNECTION CAPABILITY OF DATA GENERAL EQUIPMENTS

1. Connecting Data General MV/Family to PC client

The ability to network PC's and workstations through an organization is available for the Data General MV/Family computers.

The DAA OPEN LAN product suite unites Pcs, ECLIPSE MV/Family server systems, and mainframes into a single system for distributed operations and gives the user the freedom to choose the LAN best suited to their specific applications and environments. Part of this suite includes Data General's implementation of Novell's portable NetWare, which runs on the MV/Family platform. As multi-function servers in a Novell environment, ECLIPSE MV/Family servers run a variety of applications---communications gateways to IBM host mainframes and database services simultaneously---while integrating multiple vendors' Pcs on a common LAN.

The Data General Personal Computer Integration (DG/PC*I) platform provides communications hardware and software products that link Pcs with ECLIPSE MV/Family for distributed network computing. DG/PC*I combines the response time and wide range of single-user software of the PC with the processing, disk, and memory strengths of the ECLIPSE MV/Family systems.[Ref.7:p.16].

2. Connecting MV/Family systems

The ECLIPSE MV/Family systems can be interconnected through Data General's Message-based Reliable Channel (MRC), or through industry-standard local or wide area networks to offer users on client MV/Family systems transparent access to MV/Family data base server.

Data General allows the use of the Distributed Applications Architecture (DAA) that encompasses MV/Family to achieve MV/Family distributed computing at two sub levels through Data Generals Data Sharing Architecture, or DSA: first data base sharing among multiple ECLIPSE MV/Family systems, and secondly using ECLIPSE MV/Family systems as a highly reliable server in a broader DAA computing network.

The software components that comprise DSA include AOS/VSII, XODIAC, DG/SQL and INFOS Connection Server data management facilities.[Ref.7:p.21].

3. Connecting MV/Family to Open UNIX Systems

Data general provides the same level of interoperability between ECLIPSE MV/Family and Open UNIX systems as is provided for the MV/Family to IBM world.

The ability to interoperate with UNIX systems allows the freedom to choose the systems that are right to the user, and not force them to port their applications to a given platform. The adherence to industry standards is a critical component of Data Generals's MV/Family to Open UNIX systems

strategy. It implements UNIX standards on AOS/VS II products. TCP/IP is the industry standard communication protocol for UNIX systems available now in AOS/VS and AOS/VS II. AOS/VS II TCP/IP features faster file transfer performance due to kernel implementation and full-screen Telnet. AOS/VS II ONC/NFS lets UNIX users access AOS/VS II files and directories as if they were located on the users' own system.[Ref.7:p.31].

D. TOPOLOGY DESIGN OF THE NETWORK

The topology design of the network is a key element for success or failure of the integration of the information systems. It refers to the manner in which network devices are geometrically arranged and connected, and it determines the configuration of LAN/WAN to be used at each level of the integration. The major classes of LAN topologies are bus, ring and star. Each of these topologies has its own particular advantages and limitations in terms of reliability, expendability, and performance characteristics. The selection of best topology is based on two factors: the first one is the hardware available, and secondly the geographical location of the equipment needed to be integrated.

Based on the zone distribution of the Peruvian Air Force's information systems, the network design for the Wide Area coverage will be a hierarchical tree configuration with the central node in Lima Headquarters and with branches at the each zone of coverage.

1. General Configurations

To facilitate the integration task, three factors for the configuration need to be taken into account.

a. PC's LAN Topology

To link the IBM PC's that are dispersed all over the Units, Air Bases, and dependencies, the star topology employing the CSMA/CD medium access control and 1Base5 configuration has been chosen. The reasons behind this selection are: the low cost of star topology and the ease of its implementation in the Peruvian Air Force environment. At the LAN level integration, the protocol to be used is the IEEE 802.3. A gateway will also be required between the LANs under this topology and the hosts. This will transform the LAN frames to the WAN messages allowing compatibility in their communications.

b. WAN Configuration

To facilitate the integration of the information systems, some requirements need to be stated. First the host needs to have a Front End Communication Processor (M/F FEP) for the communication interface, which will support the linkages from the LANs, WANs, and the open UNIX systems. Secondly, to allow communication between the units or dependencies using the PSTN facility, it is necessary to use modems. This will be applied not only to the Metropolitan area integration but also to the national network integration. The

protocol to be used for the WAN integration is under the IBM environment SNA, specifically SDLC/BISYNC.

c. *International Linkage*

Transmission over PSTN is not reliable for connecting Air Attaches to the information system. Therefore, we recommend the usage of international communications carriers such as BT TYMNET and TELENET.

2. Topology Design ZONE 1

This zone covers the Metropolitan area of Lima where the Headquarters of the Peruvian Air Force are located. The integration of the information systems requires that all the information collected from the different sources---Units, Air Bases, Air-Wings, and dependencies---need to be concentrated at the Information Center CINFA. Therefore we will apply a hierarchical tree configuration with the central node in Lima Headquarters. To facilitate the topology design for this particular zone, it is divided into three areas of coverage: Las Palmas Air Base, Headquarters and Air Wing-2.

a. *Las Palmas Air Base Network Area*

This area concentrates the Supply and Maintenance services for the Peruvian Air Force. It also hosts the Peruvian Air Force Academy, the NCO's Academy, Aerophotography services and the Engineering and Contracting services. These dependencies are served by two medium-sized Data General ECLIPSE MV/15000 computers, one MV/2000, one open Unix system,

and several IBM PC's. The topology design for this Air Base area is represented in Figure 26.

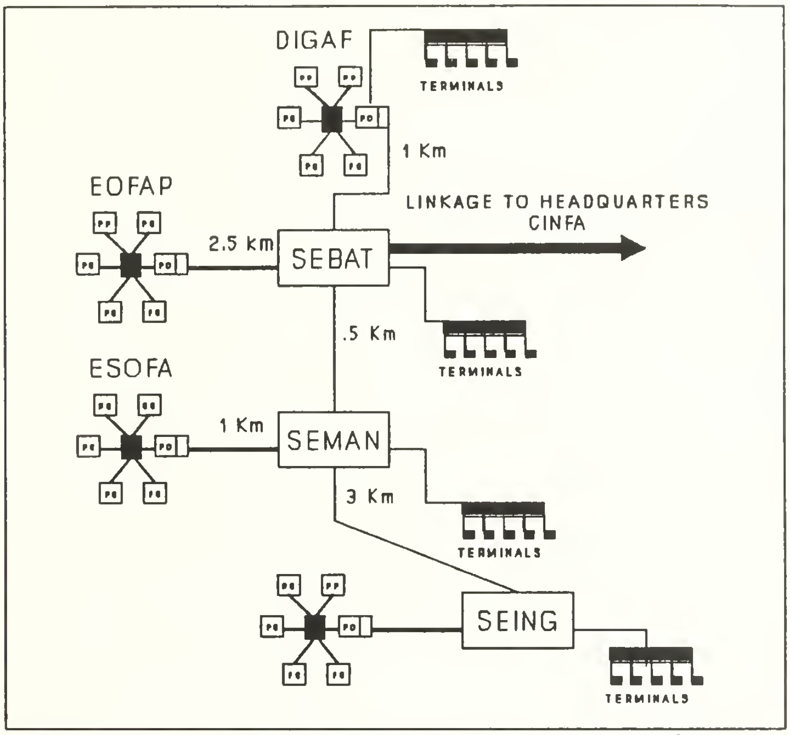


Figure 26. Las Palmas Topology Design.

b. Headquarters Area Topology Design

The Headquarters area has been chosen to be the root of the entire network throughout the country and access point of the international destinations.

The host is a Data General computer ECLIPSE MV/15000. It is linked to different LANs in the same Headquarters buildings, the WANs in the Metropolitan area of Lima, and to the Air Bases that constitute a node in each zone throughout the country.

The topology design for the Headquarters area is represented in Figure 27.

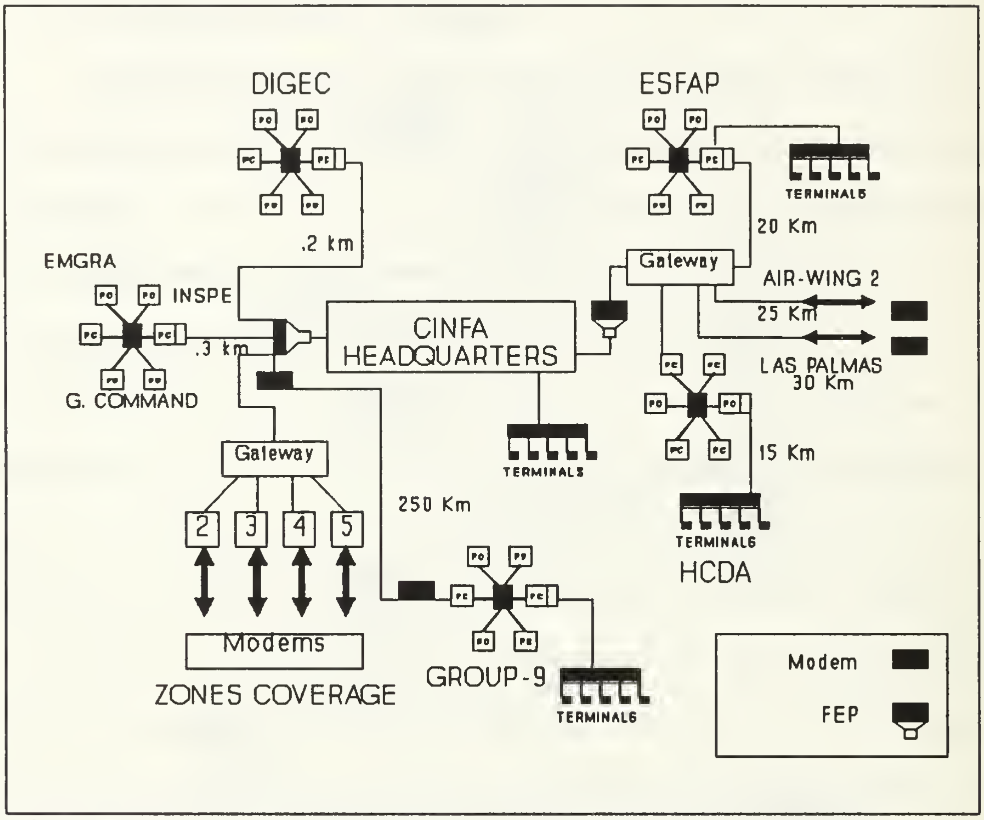


Figure 27. Headquarters area Topology Design.

c. *Air-Wing 2 Topology Design*

The Air-Wing 2 area is located at a distance of 25 kilometers from Headquarters. The information system in this area provides support to the following units: Air Group-8 and Air Group-3, and the Meteorology services of the Peruvian Air Force. The equipments available consist of a Data General minicomputer ECLIPSE MV/4000 and several PCs.

The topology design for this area is shown in Figure 28.

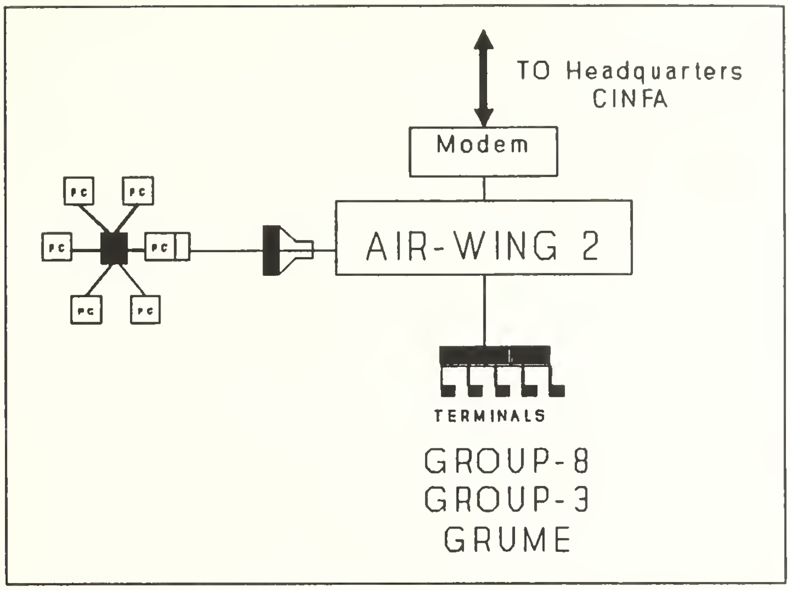


Figure 28. Air-Wing 2 Topology Design.

3. Topology Design: ZONE 2

This zone covers the southern area of the Peruvian Air Force coverage. It includes the following units: Group-4, GRUFE (Special Task Forces), and Air-Wing 3. It is located 900 kilometers from Headquarters in Lima. The unit GRUFE and the Air-Wing Command are located at a distance of 80 km from each other and 90 Km from Group-4 where the central host for this zone is located. The topology configuration is represented in Figure 29. The equipment available for the information systems integration consists of a Data General ECLIPSE MV/15000 computer, a Data General DG-30 computer, and several IBM PC's located at the Air Wing command offices.

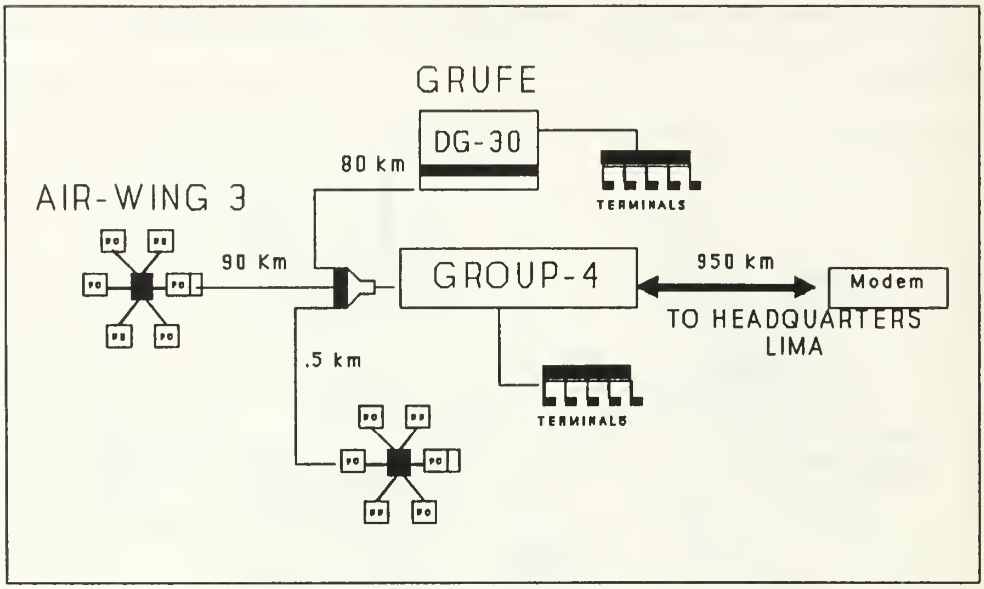


Figure 29. Zone 2 Topology Design.

4. Topology Design: ZONE 3

This zone covers the northern area of the country, and includes three units: Group-7, Group-6, Group 11, and the Air-Wing 1 Command offices. The Unit selected as the central node in this specific topology is Group-7, based on its location and computer size. The units that constitute this networking zone are separated by a distance that fluctuates from 100 to 200 Km. It is located at a distance of 850 km from the Headquarters in Lima. The equipment available for integration consists of: 3 Data General computers DG-30, and several IBM PC's located in the Air Wing Command offices. The topology design for this zone is described in the Figure 30.

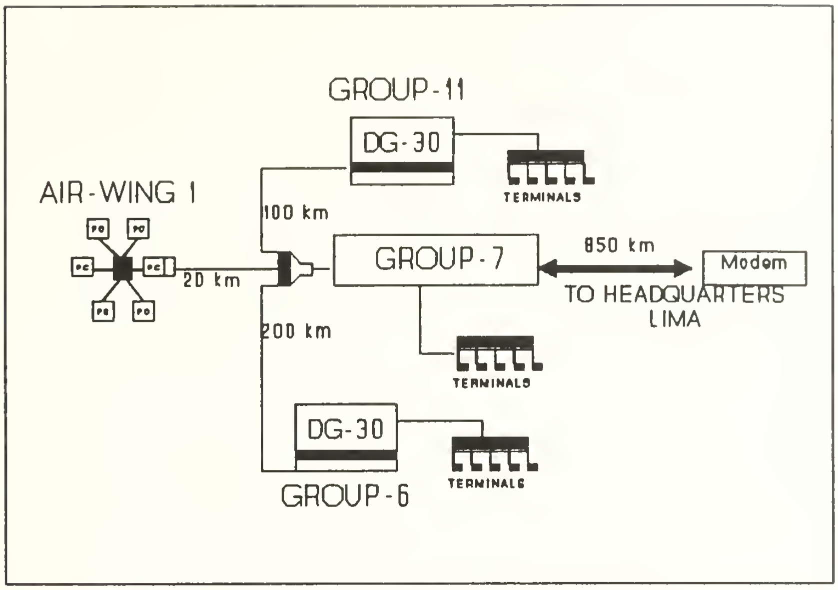


Figure 30. Topology Design ZONE 3.

5. Topology Design: ZONE 4

This zone covers the north-eastern area of the country, and integrates Group-42 and Air-Wing 5. It is geographically located 1500 kilometers from Headquarters in Lima. The equipments to be integrated consist of: a Data General computer DG-30 and several IBM PC's located in the Air wing command offices. The topology design is described in Figure 31.

6. Topology Design: ZONE 5

This zone covers the linkage with the international dependencies of the Peruvian Air Force. The Air attaches depend on several IBM PC's for their transactions. The topology design for the linkage to Headquarters in Lima is described in Figure 32.

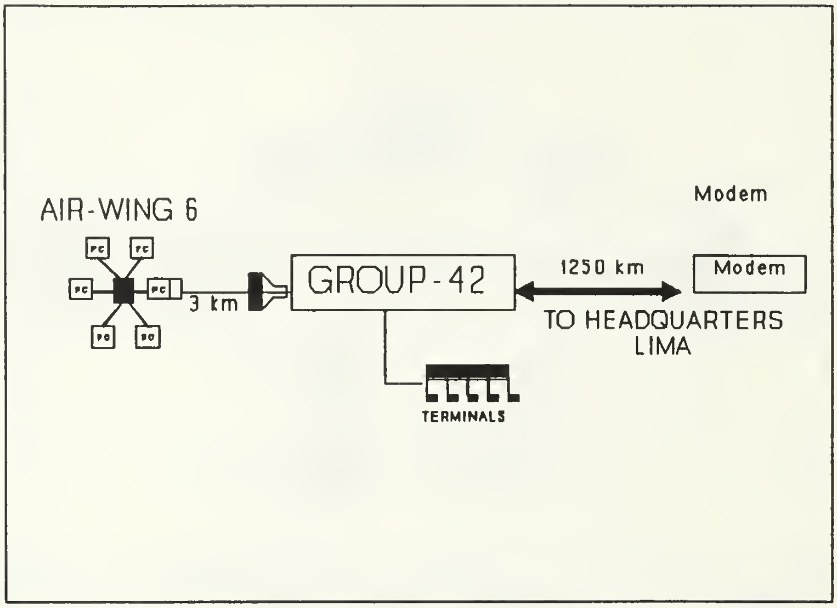


Figure 31. Zone 4 Topology Design.

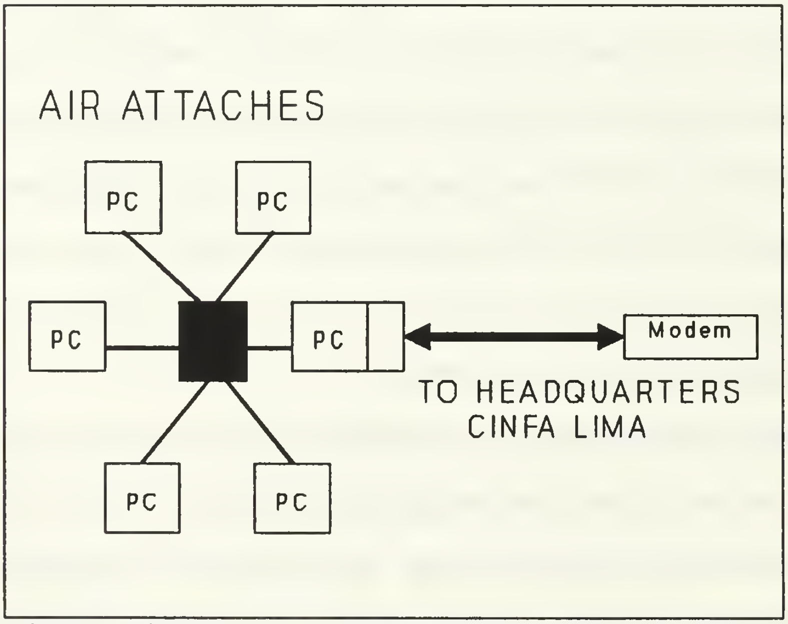


Figure 32. Air Attaches Topology Design.

E. TELECOMMUNICATION PLAN

Once the topology design of the integrated network is complete, the next phase is to establish the telecommunication plan. It will select the type of telecommunication services able to support the topology design and the transmission links that need to implemented at each instance of the integrated network system.

1. Selecting Telecommunication Service

To select the telecommunication service for each section of the network, some criteria need to be taken into account such as: the distance among the equipments required to be linked, the data rate that each channel needs to hold, and the connection time required for each equipment.

Such factors need to be considered following a step-by-step procedure in selecting the best telecommunication service. To facilitate and clarify the selection of the telecommunication service, an algorithm has been developed which can be applied to the Peruvian Air Force's information systems. The algorithm specifies the sequence of steps that need to be taken into account for the selection of the best telecommunication medium.

*** ALGORITHM ***

```
IF (TRANS-LINK FOR LAN)
    THEN
    IF (TRANS-LINK INSIDE LAN)
        THEN
        IF (COAX AVAILABLE)
            THEN
            USE COAXIAL
            ELSE
            USE TWISTED PAIR
        ELSE
        IF (DISTANCE < 5Km)
            THEN
            USE COAXIAL
            ELSE
            GOTO (WAN-TRANS-LINK)
    ELSE
 ***** WAN-TRANS-LINK
    IF (DATA-RATE > 9600)
        THEN
        USE DIGITAL LINK
        IF (T1 IS AFFORDABLE)
            THEN
            USE T1
            ELSE
            USE DDS                                    *: Depends on the
        ELSE                                              service charge
        IF (CONNECTION TIME >..*..)
            THEN
            USE DEDICATED SERVICES
            IF (DDS OR T1 AFFORDABLE)
                THEN
                USE T1, DDS
                ELSE
                USE VOICE GRADED PRIVATE LINES (VGPL)
            ELSE
            USE SWITCHED SERVICES (PSTN)
```

Since the LANs are required to be standardized, the internal linkage for the LAN will use coaxial cable if it is available; if not, twisted-pair wire will be used.

2. Transmission Links

Based on the algorithm the selection for the transmission links has been made. Table 4. describes the transmission media for each link.

TABLE 4. TRANSMISSION LINKS.

FROM	TO	TRANS-LINK	ALTERNATIVE
EOFAP-LAN	SEBAT	COAX	N.A
ESOFA-LAN	SEMAN	COAX	N.A
SEING-LAN	SEING	COAX	N.A
SEING	SEMAN	COAX	N.A
SEMAN	SEBAT	COAX	N.A
DIGAF	SEBAT	COAX	N.A
SEBAT	CINFA	PSTN	VGPL,DDS,T1
DIGEC-LAN	CINFA	COAX	N.A
EMGRA-LAN	CINFA	COAX	N.A
HCDA-LAN	CINFA	PSTN	VGPL
ESFAP	CINFA	PSTN	VGPL
GROUP-9	CINFA	PSTN	N.A
AIR-WING 2	CINFA	PSTN	VGPL
ZONE 2	CINFA	PSTN	VGPL,DDS,T1
ZONE 3	CINFA	PSTN	VGPL,DDS,T1
ZONE 4	CINFA	PSTN	VGPL,DDS,T1
ZONE 5	CINFA	INT.COMM.POP	TYMNET TELNET
GP-8 LAN	AIR-WING 2	COAX	N.A
AIR-WING 3	GROUP-4	PSTN	VGPL
GRUFE	GROUP-4	PSTN	VGPL
GP-4 LAN	GROUP-4	COAX	N.A

FROM	TO	TRANS-LINK	ALTERNATIVE
AIR-WING 1	GROUP-7	PSTN	VGPL
GROUP-6	GROUP-7	PSTN	VGPL
GROUP-11	GROUP-7	PSTN	VGPL
AIR-WING 6	GROUP-42	COAX	PSTN

The data rate requirements and the connection time necessary for the interconnection are relatively low. In most cases the usage of PSTN will satisfy the data demand. However as the system grows and new applications are implemented, a different transmission link may be required. In some of the transmission linkages, the alternative of using VGPL is given. This alternative gives a dedicated transmission channel as the system grows, its use would diminish the charge of switched services from the phone companies.

As stated previously, the transmission link to be used to integrate the Air Attaches abroad will require the use of international communication carriers such as: BT TYMNET, TELNET, and others available in Peru. The reason for that is that PSTN is not reliable for this kind of communications.

Twisted pairs are described by their size. The sizing system in the USA is called American Wire Gauge (AWG) system. The AWG specifies the diameter of the wire; the higher-gauge numbers indicate thinner wire sizes. The smaller the diameter of the wire, the greater the resistance to the propagation on the signal. Local telephone loops are usually 22 to 26 gauge. The bulk of telephone twisted pairs (TTP) use 24 gauge. At a transmission speed of 2.4 Kbit/sec the average distance is 15 Km.[Ref.8:p.419-421].

The coaxial cable recommended as a transmission medium has to comply with the specifications of baseland coaxial cable (50 OHMs).[Ref.8:p.423].

F. PROTOCOLS

A protocol is a strict set of rules or procedures that are required to initiate and maintain communications. Simply put, a protocol is a set of rules that allow two or more end points to communicate. Protocols consist of syntax, semantics, and timing. The syntax of a protocol defines the bit stream by dividing it into frames. Semantics defines the precise meaning of the bits within the frame. Timing includes the data rate, the bit stream, and pauses between acknowledgments in half duplex transmission. The international standard protocol syntax and semantics are defined in the Open System Interconnection (OSI).

For the integration of the Peruvian Air Force's information systems, the selection of the protocols must be based on the compliance and capabilities of the equipments and the OSI standards. Figure 33. represents the DAA Data General Open LAN Communication Protocol configuration.[Ref.6:p.31-45].

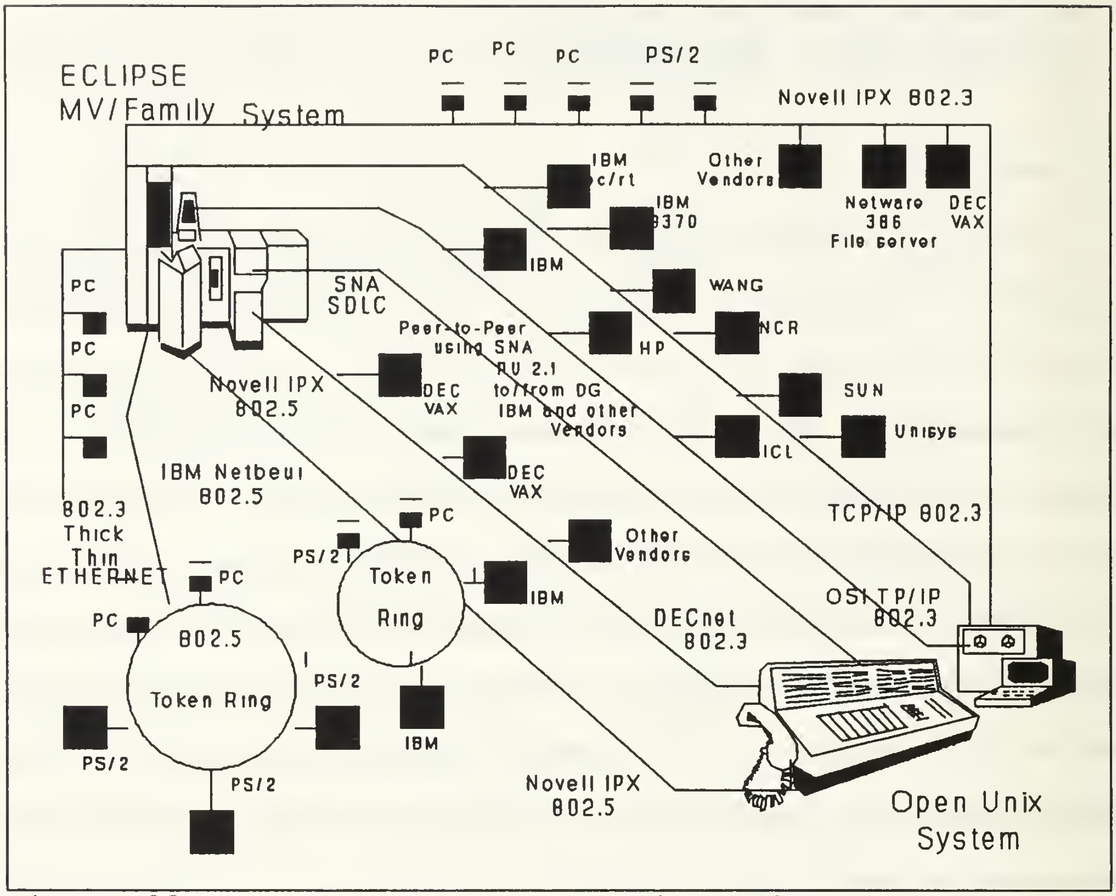


Figure 33. Open LAN Protocol Configuration.

1. LAN Protocol Selection

The protocol to be used in the LAN configuration is the IEEE 802.3. The IEEE standard 802.3 CSMA/CD access control method is the most commonly used access method for LANs employing bus topology. This protocol is commonly described as *listen while talk*. The station that has to transmit first senses the medium. If the medium is quiet, the station begins transmitting. Otherwise, it waits for a random period of time before trying to transmit.[Ref.9:p.235].

2. WAN Protocol selection

The IBM environment is allowed in the Data General computers ECLIPSE MV/Family. Therefore the operation in the Systems Network Architecture (SNA) is possible. SNA describes an integrated structure that provides for all modes of data communications and upon which new data communication networks can be planned and implemented. SNA is built around four basic principles. First, SNA encompasses distributed functions. Second, SNA describes paths between users of the data communication network separately from the users themselves. Third, SNA uses the principle of device independence, and fourth, SNA uses both logical and physical standardized functions and protocols for the communication of the information between any two points.

Specifically the protocol to be used in the IBM environment is SNA SDLC/BYSINC.[Ref.10:p.417-441].

3. Protocols for International Links

For the interconnection of the international dependencies of the Peruvian air Force, the protocol selected is X.25 since it is the most popular international bit-oriented protocol, and complies with the requirements to use the international communication carriers such as BT TYMNET, and TELNET.[Ref.11:p.321].

4. Gateway Protocol Converter Considerations

Protocol converters are hardware or software utilized to interconnect two dissimilar computer systems or terminals so they can talk to each other. In general, the basic approaches to protocol conversion can be divided in three categories: hardware protocol conversion boxes, add-on circuit boards for microcomputers, and software that resides in the host mainframe computers.

In our specific case the usage of a protocol converter in each of the gateways will be required to transform the PC-frame format of the LAN configuration IEEE 802.3 CSMA/CD to SDLC/BYSINC throughout the integrated network system.

G. COMMUNICATIONS SOFTWARE

This section will describe communication softwares used to establish the integrated environment of the Peruvian Air Force's information systems.

1. TCP/IP Communications Software

Data General's Transmission Control Protocol/Internet Protocol (TCP/IP) communication software lets users transfer files, send mail, and log on to remote hosts in multi-vendor and heterogeneous networking environments. TCP/IP is supported by Data General AOS/VS, AOS/VS II.[Ref.12:p.5].

a. Features and Benefits

It is available in Data General DG/UX, AOS/VS, AOS/VS II based systems, and provides interoperability between ECLIPSE MV/Family, AViiON and 386/ix systems.

It provides the industry standard protocol suite which includes TCP/IP, Telnet, FTP, SMTP, UDP, ICMP, and ARP. It supports data communications between heterogeneous hosts with diverse operating systems. It also supports communications between PC's running TCP/IP.[Ref.12:p.7-10].

b. Applications

Data General TCP/IP communications software implements three primary applications: *Telnet, FTP,* and *send-mail,* which contains the Simple Mail Transfer Protocol. AOS/VS II supports *rmt,rlp,* and *rsb*.[Ref.12:p.12].

2. XODIAC Transport Services II

Xodiac Transport Services (XTS) II provides a common, standard-based transport platform for a variety of communications applications including the XODIAC networking architecture, DG/PC*1, and the Data Sharing Architecture. In addition, transport services for Data General/OSI Communications Architecture are available through Data General/OSI Transport Services (DG/OTS) a superset of XTS II.

A number of physical connection schemes are supported by XTS II including StarLAN, ETHERNET 802.3 and RS-232/V.24 for leased or PDN connections. XTS II conforms to the 1984

CCITT X.25 protocol including optional facilities, and it provides high performance connection to any system supporting X.25.[Ref.13:p.24-31].

a. *Features and Benefits*

Based upon formal industry standards, it enables interoperability between Data General's and other vendors' systems that support the X.25 protocol.

XODIAC Data General Personal Computer*Integration (DG/PC*I) and Data Sharing Architecture provide transport services for a wide range of communications and networking configurations. Wide area network (WAN) and Local area network (LAN) services interoperate over a wealth of physical connectivity options. Management capabilities under the Network Operator Process (NETOP) or DG/Open Network Management System (DG/Open NMS) allows flexibility in network management.[Ref.13:p.32-37].

b. *Networking Applications*

XODIAC is a family of software products that enable MV/Family systems to share resources and exchange data in a comprehensive and complete manner over LANs and WANs.

XTS II supports XODIAC with X.25 network access, routing, and other functions needed to form end-to-end connections between remote systems.

XTS II provides transport services for DG/PC*I via NETBIOS interface. The XTS II TSWVTA (Terminal Services

Workstation Virtual Terminal Agent) provides PC users with terminal emulation capabilities on MV/Family systems.[Ref.12:p.42-47].

3. Netware for MV/Family Systems

It is a Data General's AOS/VS hosted version of Novell's Portable Netware PC LAN server operating system. It offers a powerful, standard-based solution to local area networking. NetWare for MV/Family Systems integrates ECLIPSE MV/Family hosts and heterogeneous workstations into a unified, network computing environment. Macintosh, UNIX, DOS, and OS/2 workstations can all communicate through MV/Family servers running Portable NetWare, while utilizing the MV/Family hosts' services. Users have the maximum flexibility and freedom to choose the workstations and operating systems best suited to their application needs.[Ref.14:p.3-5].

a. Features and Benefits

It provides high performance connectivity solution for ECLIPSE MV/Family systems, and interoperates with existing and future LANs. It is a multi-function ECLIPSE MV/Family PC LAN server. It supports Macintosh, DOS, Windows/386 and OS/2 Pcs. It ensures seamless connectivity between multiple Pcs and MV/Family host providing transparent print services and file access.[Ref.14:p.6-9].

4. DG/Open Network Management System

(DG/Open MNS) is an interactive menu-based software product set that manages and supports network monitoring and control functions in XODIAC and (DG/PC*I) network environments. DG/Open MNS runs on the entire range of Data General ECLIPSE MV/Family minicomputers and the AOS/VS operating systems. It is based on the currently evolving Open Systems Interconnection (OSI) network management architecture model by the International Standards Organization (ISO).[Ref.15:p.5].

a. Features and Benefits

It provides growth path by supporting XODIAC and DG/PC*I networks and multivendor networks that follow the standard the future. It decreases requirements for multi-site systems administration expertise on large, distributed networks. It enables users to manage networks according to their organizational requirements, and minimizes use of network resources by avoiding unnecessary management traffic. It enables operators to isolate and respond to network and system faults on local and remote systems. It allows users to tailor their security needs to internal administrative requirements. It aids in network operations management and planning, permits customized analysis and enables users to manage their own resources and products.[Ref.15:p.7-13].

V. CONCLUSIONS

A. FINDINGS

Based on the exhaustive analysis of the Peruvian Air Force information systems, some factors that determine the status-quo and the limitations of the current information systems are identified.

The software presently in use was developed over a decade ago under inadequate standards for software development, creating problems as a consequence of undocumented applications, unstructured programming techniques, and poor data base design. Considerable available human resources are dedicated to repair and maintain the systems and applications currently used.

Data is found to be redundant and inconsistent due to the improper data base design and the lack of integration of the information systems. Based on these constraints and acknowledgement of the problem, a project is underway to restructure existing systems and develop new systems under the standards of software development and well-planned data base design.

The Peruvian Air Force's Information Systems Command acknowledges the necessity for integration. However the economical resources to implement an integrated system had

been limited in past attempts. Furthermore there was a lack of coordination between the Information Center Command CINFA and the Communications and Electronics Command in the Peruvian Air Force, thus creating a confusion on the communications plans for the information systems.

The design of the network integration for the purpose of this thesis had to comply with limited economic resources and the technology available in the environment of the Peruvian Air Force's information systems. The network integration for the Peruvian Air Force is feasible due to the characteristics of the host computers and the standards of communication that they allow. There is a substantial effort to improve on communication software and applications to support the Peruvian Air Force's information systems in an integrated environment.

B. RECOMMENDATIONS

1. Software Development

It is important to base the design of the integrated system on a well-planned data base that could eliminate the problems of redundancy and inconsistency that currently occur.

This development should comply with the standards and rules of software design. It will substantially diminish the waste of human resources maintaining and supporting a system without documentation, and it will improve the effectiveness of the entire system.

2. Management and Organization

The implications of an integrated network system must be understood by the Air Force Command. It needs to recognize the wide range of new possibilities that will be open with its utilization.

The Information Center CINFA must consider the necessity to train its personnel for the use and effective operation of the integrated network system.

Meetings with the Communications and Electronics Command in the Peruvian Air Force is required to establish the technical requirements for the communication channels that will be installed by them for the integrated network, and with Peruvian Phone Company (CPT) to asses the charges, fees and restraints on using VGPL and PSTN.

3. Telecommunication Plan

The current network design will satisfy the necessities of the current system; however the consideration that the system will grow must be taken into account.

To design an integrated network, the analysis of the current system must identify such factors as data rate demand, frequency of communication sessions, location of the computer based systems, hardware availability, and software support. These factors are currently being analyzed and compiled for the information systems at the Peruvian Air Force; however in the long run they are subject to change and then new

requirements for transmission media, communication software, and topology of the network may arise.

As it was stated in Chapter IV of this thesis the transmission media not only will depend on the data rate requirement, but also on the connection time. If the connection time is too long, that will probably drive us to the use of private lines instead of PSTN. These are considerations that need to be taken into account. Which of the many alternatives given in the thesis is best will be based on the environment in which the integrated network will operate.

LIST OF REFERENCES

1. Georry, G., Anthony, B., Scott-Morton, M.S., *A Framework for Management Information Systems*, v.13, n.1, Sloan Management Review, 1979.

2. Georry, G., Anthony, B., Scott-Morton, M.S., *A framework for Management Information Systems*, v.13, n.3, Sloan Management Review, 1979.

3. Georry, G., Anthony, B., Scott-Morton, M.S., *A framework for Management Information Systems*, v.29, Sloan Management Review, 1983.

4. Davis, G.B. and Olson, M.H., *Management Information Systems-Conceptual Foundations, Structure and Development*, McGraw-Hill, Inc., 1985.

5. Data General Corporation, *Eclipse M/V FAMILY Strategy,* 2nd ed., v.1, 1990.

6. Data General Corporation, *DAA Open LAN Interoperability,* 2nd ed., v.1, 1990.

7. Data General Corporation, *The Eclipse M/V Family in the world of DAA,* 1th ed., v.1, 1990.

8. Fitzgerald, J., *Business Data Communications,* 3th ed., John Wiley and Sons Inc., 1990.

9. Burg, F.M., Chang, T.C., *Of Local Protocols and OSI reference Model,* v.13, Data Communications 1985.

10. Aschenbrenner, J.R., *Open Systems Interconnection,* v.25, IBM Systems Journal n.4, 1987.

11. McConnel, J., *Internetworking Computer Systems,* 1th ed., v.1, Prentice-Hall Inc., 1988.

12. Data General Corporation, *TCP/IP Communication Software Manual,* 3th ed., v.1, 1989.

13. Data General Corporation, *XODIAC Transport Services Manual,* 1th ed., v.2, 1990.

14. Data General Corporation, *Netware for MV/Family Systems,* 2nd ed., v.1, 1990.

15. Data General Corporation, *DG/Open Network Management System*, 2nd ed., v.2, 1988.

BIBLIOGRAPHY

Black. U., "Data Networks: Concepts, Theory, and practice"; **Prentice Hall Inc.**, 1989.

Comer. D., "Internetworking with TCP/IP: Principles, Protocols and Architectures"; **Prentice Hall Inc.**, 1989.

Keen. P., and Marton. S., "Decion Support Systems: An Organizational Perspective", **Addison-Wesley**, 1978.

Kroenke. D., "Database Processing: Fundamentals, Design, Implementation"; **Mcmillan**, 1988.

Schwatz. M., "Telecommunications Networks:Protocols, Modeling, and Analysis"; **Addison-Wesley**, 1988.

Stalling. W., "Data Computer Communications"; **Mcmillan [2nd ed.]**, 1988.

Tanenbaum. A., "Computer Networks"; **Prentice Hall [2nd ed.]**, 1988.

Skalar, Bernard, "Digital Communications. Fundamentals and Applications", **Prentice Hall**, 1988.

Suh, Myung W., Material Support of Computer Networks Course [IS 3502], **Naval Postgraduate School**, July 1990.

Suh, Myung W., Material Support of Network Telecommunications Course [IS 4502], **Naval Postgraduate School**, January 1991.

Levine, Judith, "Networking for Desert Shield,"; **Communications Week**, 14 January 1991.

Stanley. William., "Electronic Communications Systems"; **Prentice Hall**, 1982.

Schilling. Donald L., "Spread spectrum Personal Communication Network"; **SCS Telcom, Inc.**, January, 1990.

Ginn. Sam., "Personal Communication services: Expanding the Freedom to Communicate"; **IEEE Communications Magazine**, February, 1991.

Peruvian Air Force., "Ordenanza 20-54"; Normative document for the Peruvian air Force information systems, **Peruvian Air Force Command**.

McConnell, J., "Internetworking Computer Systems". Englewood Cliffs, **Prentice Hall Inc.**, 1988.

Stallings, William. "Data and Computer Communications" **MacMillan Publishing Company**, 1985.

Fizgerald, J., "Business Data Communications Basic Concepts, Security and Design" 3th ed., **John Wiley and Sons Inc.**, 1990.

Fuerza Aerea Peruana, Direccion de Informatica, "Integracion del Systema de Informacion FAP", **Imprenta FAP**, Lima, Peru., 1989.

Qinones A., "Integracion de los Centros de Computo de la Fuerza Aerea Peruana", Trabajo de eficiencia profesional para optar el grado de Coronel FAP, **Imprenta FAP**, Lima, Peru., 1989.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, VA 22304-6145	2
2.	Library, Code 52 Naval Postgraduate School Monterey, CA 93943-5002	2
3.	Comando de Instruccion de la Fuerza Aerea del Peru. Cuartel general de la Fuerza Aerea Peruana Lima, Republica del Peru	1
4.	Direccion de Informatica de la Fuerza Aerea del Peru. Cuartel General de la Fuerza Aerea Peruana Lima, Republica del Peru.	3
5.	Escuela de Oficiales de la Fuerza Aerea Peruana. Biblioteca del Grupo de Instruccion. Base Aerea "Las Palmas", Surco, Lima, Republica del Peru.	2
6.	Escuela de capacitamiento (ESCAP) de la Fuerza Aerea del Peru. Surco, Lima, Republica del Peru.	1
7.	Escuela Superior de la Fuerza Aerea del Peru (ESFAP). Cuartel General de la Fuerza Aerea Peruana Lima, Republica del Peru.	2